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BEING THE

ANNUAL REPORTS

OF VARIOUS

PUBLIC OFFICERS AND INSTITUTIONS

FOR THE YEAR

1893.

PUBLISHED BY THE SECRETARY OF THE COMMONWEALTH.

Vol. IV.

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TWENTY-FIFTH ANNUAL REPORT

OF THE

STATE BOARD OF HEALTH

OF

MASSACHUSETTS.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1894.

MEMBERS OF THE BOARD.

1893–1894.

HENRY P. WALCOTT, M.D., *Chairman*, ... of CAMBRIDGE.
JOSEPH W. HASTINGS, M.D., ... of WARREN.
HIRAM F. MILLS, C.E., ... of LAWRENCE.
FRANK W. DRAPER, M.D., ... of BOSTON.
GERARD C. TOBEY, ESQ., ... of WAREHAM.
JAMES W. HULL, ... of PITTSFIELD.
ELIJAH U. JONES, M.D.,* . . . . of TAUNTON.
CHARLES H. PORTER, ... of QUINCY.

Secretary.

SAMUEL W. ABBOTT, M.D.

Engineer.

F. P. STEARNS, C.E.

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* Died November, 1893.

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GENERAL REPORT.

The following report comprises the general work of the State Board of Health of Massachusetts for the year ending Sept. 30, 1893.

The following are the subjects embraced in this report: —

REPORT TO THE LEGISLATURE UPON WATER SUPPLY AND SEWERAGE, INCLUDING THE ADVICE OF THE BOARD GIVEN UNDER THE PROVISIONS OF CHAPTER 375 OF THE ACTS OF 1888.

SUMMARY OF WEEKLY MORTALITY RETURNS FROM CITIES AND TOWNS.

REPORTS OF INFECTIOUS DISEASES.

REPORTS UPON FOOD AND DRUG INSPECTION.

INFECTIOUS DISEASE HOSPITALS.

HEALTH OF TOWNS.

The following members comprised the Board in 1893: —

HENRY P. WALCOTT, *Chairman.*

FRANK W. DRAPER.	JOSEPH W. HASTINGS.
HIRAM F. MILLS.	GERARD C. TOBEY.
ELIJAH U. JONES.	MORRIS SCHAFF.

J. H. Raymond resigned in January, and G. C. Tobey of Wareham was appointed in his place.

General Schaff resigned in August, 1893, and J. W. Hull of Pittsfield was appointed in his place.

Dr. Elijah U. Jones of Taunton died in November, 1893. He had been a member of the Board since its reorganization in 1886, and had taken a deep and continued interest in the work of the Board from the beginning of his connection with it.

C. H. Porter of Quincy was appointed in February, 1894, to fill the place made vacant by the death of Dr. Jones.

Infectious Diseases.

Small-pox.

During the ten years ending with 1892, the State had been comparatively exempt from small-pox, the average annual number of deaths from this cause in the State for the ten years 1883–92 being less than five, or two and one-half per million inhabitants; and, while the same statement of exemption is true of nearly all of the United States for the same period, it is almost unparalleled in the experience of any foreign country except Germany and Sweden.

The following table presents the comparative mortality of several countries from this cause for a period of four years: —

Average Annual Mortality from Small-pox per Million Inhabitants, 1886–1889, Four Years.

COUNTRIES.	Annual Death-rate per Million Inhabitants from Small-pox.
Germany,	3.5
Sweden,	0.9
Belgium,	164.0
Great Britain,	15.0
Italy,	536.0
Holland,	5.7
Austria,	471.0
Russia (European),	231.0
Switzerland,	18.5
Spain,	963.0
MASSACHUSETTS,	2.1*

* The epidemic of 1893–94 increases this average to about 3.6 per million inhabitants for a period of ten years.

The unusual immunity of Germany, with a population of nearly fifty millions, surrounded and menaced by countries with an almost constant prevalence of small-pox, is undoubtedly due largely to the excellence of its vaccination laws and the thorough manner of their enforcement.

In 1883 a statute was enacted in Massachusetts requiring that every case of small-pox should be reported to the State Board of Health. Soon after the enactment of this statute a circular was prepared in which not only the fact of the existence of the disease was recognized but also other facts which were deemed essential to a complete record.

From these notices the following statistics are compiled for the nine years ending with 1893 : —

Small-pox in Massachusetts, 1885–1893.

Years.	Small-pox.			Vaccinated.			Unvaccinated.			Doubtful or Unknown.		
	Total Cases.	Total Deaths.	Per Cent.	Cases.	Deaths.	Per Cent.	Cases.	Deaths.	Per Cent.	Cases.	Deaths.	Per Cent.
1885, . .	32	11	-	7	0	-	13	9	-	12	2	-
1886, . .	2	1	-	1	1	-	-	-	-	1	0	-
1887, . .	13	4	-	6	0	-	5	2	-	2	2	-
1888, . .	32	5	-	15	1	-	13	3	-	4	1	-
1889, . .	15	3	-	11	1	-	3	1	-	1	1	-
1890, . .	6	1	-	2	-	-	2	-	-	2	1	-
1891, . .	5	1	-	1	-	-	3	1	-	1	-	-
1892, . .	19	2	-	7	-	-	10	1	-	2	1	-
1893, . .	44	6	-	11	0	-	27	6	-	6	0	-
	168	34	20.2	61	3	4.9	76	23	30.3	31	8	25.8

Summary. — There were in all 168 reported cases in the nine years (1885–93), and 34 deaths, or 20.2 per cent. of the whole.

Of this number 61 were vaccinated, and of these 3 or only 4.9 per cent. died.

The unvaccinated were 76 in number, of whom 23 or 30.3 per cent. died.

There were also 31 in whom the facts as to vaccination were doubtful or not reported, and of this number 8 or 25.8 per cent. died.

By this it appears that the vaccinated had, as compared with the unvaccinated, a six-fold immunity from death by small-pox, which corresponds fairly with other observations upon larger numbers. To this statement it should be added that in very many of the cases recorded as vaccinated, and especially among adults, there had been but one vaccination, and often a single scar only, and that of an imperfect character.

The following table contains the principal items gathered from the reports of cases of small-pox made to the State Board of Health under the provisions of chapter 138 of the Acts of 1883 during the year 1893.

Record of Cases of Small-pox reported to the State Board of Health during the Year 1893, under the Provisions of Chapter 138 of the Acts of 1883.

Number.	Date of Report.	Place of Occurrence.	Nationality of Patient.	Occupation.	Age.	Sex.	Previously Vaccinated.	Number of Scars.	Deaths.
1	Jan. 9,	New Bedford, .	Portuguese, .	Housewife, . .	25 years.	F.	Yes	-	-
2	Jan. 9,	New Bedford, .	Portuguese, .	- -	16 mos.	F.	Yes.	-	-
3	Jan. 29,	Westfield, . .	American, . .	Father an iron-moulder.	14 years.	M.	No.	-	-
4	Jan. 29,	Westfield, . .	American, . .	Whip maker, . .	16 "	M.	No.	-	-
5	Jan. 29,	Westfield, . .	American, . .	- -	12 "	M.	No.	-	-
6	Jan. 29,	Westfield, . .	American, . .	- -	5 mos.	F	No.	-	1
7	Jan. 29,	Westfield, . .	American, . .	- -	5 years.	M.	No.	-	1
8	Feb. 17,	Springfield, .	Irish, . . .	Brass worker, .	25 years.	M.	Yes.	1	-
9	Mar. 4,	Springfield, .	American, . .	Corset maker, .	28 "	F.	No.	-	-
10	Mar. 26,	Westfield, . .	German, . .	- -	Adult.	M.	-	-	-
11	April 3,	Westfield, . .	Fr. Canadian, .	- -	Adult.	F.	-	-	-
12	April 12,	North Adams, .	Irish, . . .	Rag cutter, . .	15 "	F.	Yes.	-	-
13	June 5,	Pepperell, . .	French, . .	Rag sorter, . .	22 "	F.	No.	-	-
14	Sept. 21,	Holyoke, . .	Italian, . .	Bookbinder, . .	35 years.	M.	Yes.	1	-
15	Oct. 2,	Holyoke, . .	Italian, . .	- -	1 year.	M.	No.	1	-
16	Oct. 8,	Holyoke, . .	Fr. Canadian, .	Housewife, . .	40 years.	F.	No.	-	-
17	Oct. 20,	Boston, . .	English, . .	- -	11 "	M.	Yes.	2	-
18	Nov. 6,	Boston, . .	Irish, . . .	Laborer, . . .	17 "	M.	No.	-	-
19	Nov. 13,	Boston, . .	Irish, . . .	- -	13 "	F.	Yes.	2	-
20	Nov. 13,	Boston, . .	Irish, . . .	Housewife, . .	25 "	F.	Yes.	3	-
21	Nov. 13,	Boston, . .	American, . .	- -	3 "	F.	No.	-	-
22	Nov. 13,	Boston, . .	American, . .	- -	1y. 9m.	M.	No.	-	-
23	Nov. 18,	Boston, . .	American, . .	- -	4 years.	F.	No.	-	-
24	Nov. 19,	Boston, . .	Irish, . . .	Stableman, . .	28 "	M.	Yes.	2	-
25	Nov. 19,	Boston, . .	Irish, . . .	Housewife, . .	30 "	F.	Yes.	2	-
26	Dec. 7,	Boston, . .	Br. Provinces, .	Schoolboy, . .	14 "	M.	-	0	-
27	Dec. 7,	Boston, . .	Br. Provinces, .	Errand boy, . .	17 "	M.	No.	-	-
28	Dec. 7,	Boston, . .	Br. Provinces, .	Salesman, . .	22 "	M.	No.	-	-
29	Dec. 8,	Boston, . .	Br. Provinces, .	Table girl, . .	20 "	F.	No.	-	-
30	Dec. 8,	Boston, . .	Br. Provinces, .	School girl, . .	10 "	F.	No.	-	-
31	Dec. 8,	Boston, . .	Br. Provinces, .	- -	15 "	F.	No.	-	-
32	Dec. 8,	Boston, . .	Br. Provinces, .	- -	19 "	F.	No.	-	1
33	Dec. 9,	Boston, . .	Br. Provinces, .	Carpenter, . .	54 "	M.	Yes.	2	-
34	Dec. 9,	Boston, . .	Br. Provinces, .	- -	26 "	F.	No.	-	1
35	Dec. 10,	Boston, . .	Br. Provinces, .	Domestic, . .	19 "	F.	No.	-	-
36	Dec. 12,	Somerville, .	Br. Provinces, .	Harness maker, .	18 "	M.	No.	-	-
37	Dec. 13,	Boston, . .	American, . .	- -	1 mo.	F.	No.	-	1
38	Dec. 14,	Boston, . .	Br. Provinces, .	Domestic, . .	18 years.	F.	-	-	-
39	Dec. 15,	Boston, . .	Br. Provinces, .	Domestic, . .	20 "	F.	-	-	-
40	Dec. 16,	Boston, . .	Br. Provinces, .	Domestic, . .	21 "	F.	No.	-	1
41	Dec. 21,	Boston, . .	Br. Provinces, .	Housewife, . .	24 "	F.	No.	-	-
42	Dec. 23,	Boston, . .	Br. Provinces, .	Domestic, . .	19 "	F.	No.	-	-
43	Dec. 23,	Boston, . .	Br. Provinces, .	Shoemaker, . .	25 "	M.	No.	-	-
44	Dec. 26,	Lowell, . .	- -	- -	22 "	M.	-	-	-

NOTES. — 1, 2. Vaccinated about seven months since. 4 and 5. Vaccinated unsuccessfully when a child; no further attempt was made. 8. Vaccinated twenty-four and eighteen years ago, and had varioloid. 9. Contracted from No. 3. 12. Vaccinated six years since. 14. Vaccinated twenty-five years ago; one small scar. 15. Vaccinated ten days before. 17. Imperfect scars. 19. Vaccinated in infancy; contracted small-pox on steamer "Catalonia," from Liverpool. 20. Vaccinated in infancy and nine years ago. Nos. 18, 19 and 20 were contracted from No. 17. 24. Vaccinated in infancy and November 6; contracted from No. 16. 25. Vaccinated in infancy and November 6. 33. Vaccinated in infancy; two imperfect scars. 38. Vaccinated December 8; too late to take effect. 39. Vaccinated December 7.

These forty-four cases present several points which are worthy of note. Most of the cases (43 out of 44) occurred in the cities and large towns. Out of the first sixteen cases which occurred during the year, eleven occurred in places where paper mills using rags exist. There has been no serious epidemic of small-pox in the

State during the past twenty-five years in which cases have not occurred in considerable numbers in such cities and towns, and while only two of the persons in the foregoing list are reported as being employed in handling rags, several of the others are known to have lived in the same families or tenements with persons so employed.

Ten only out of the forty-four are reported as having been of American birth.

Out of the whole number 25 or 56.8 per cent. were females, a circumstance which is quite unusual since the majority of cases are commonly men.

Of the whole number, 8 were under five years of age, 6 were school-children or children of school age, eight to fourteen years, and of these, 3 were unvaccinated.

Vaccination. — In consequence of the unusual prevalence of small-pox during the past season it seems proper to state some of the principles relating to vaccination as clearly as possible.

The experience of nearly a century with vaccination has demonstrated its protective power beyond a reasonable doubt. This power, however, is not absolute, nor does it continue throughout adult life. Hence it is desirable that revaccination should be performed at or before the period of puberty.

The provisions of the German law afford a very good rule in this respect. It is therein required that every child shall be vaccinated before the September of the year following its birth, and that every school-child shall be re-vaccinated during its twelfth year.

The result of the enactment of this law in 1874 has been the almost complete extinction of small-pox in Germany since that date. In the six largest cities of the empire the mortality from small-pox was reduced from 92 per 100,000 of the population to 1.4 in the ten years after the enactment of the law.

The opposition to the practice of vaccination is by no means new. It is coeval with the discovery of this extremely valuable means of disease prevention, and the past century has developed nothing new on the part of its opponents, while vaccination itself has received the strongest support in the brilliant researches of Pasteur and others in the direction of protective inoculation for other diseases.

The first secretary of the State Board of Health, Dr. Derby, said of vaccination: —

We may turn the question with ingenious skill, so that its many facets shall reflect a multitude of curious lights, and after all we find that we rest in a security against this most horrid pestilence unknown to former generations.

The operation of vaccination should always be conducted with the greatest care. The following rules (modified from those of the Local Government Board of England) may be observed with advantage: —

1. In the vaccination of infants ascertain that there is not any febrile condition, or irritation of the bowels, or an unhealthy state of the skin; especially any chafing or eczema behind the ears or in the groin, or elsewhere in the folds of the skin. Where there has been recent exposure to the infection of measles or scarlet-fever, and where erysipelas prevails in the place of residence, vaccination should be delayed for a month, or until danger of other infection has passed.

2. In all ordinary cases of primary vaccination, make at least two insertions of lymph not less than a half inch apart. It is desirable that the total area of vesiculation on the same day of the week following the vaccination should amount to not less than a half of a square inch.

3. Direct that care be taken for keeping the vesicles uninjured during their progress, and for avoiding the premature removal of the crusts. Do not use any needless means of "protection" or of "dressing" to a vaccinated arm; but, if in a particular case, you find reason for means of "protection" or of "dressing," define the material and the manner of use of the appliances best adapted to the case, avoiding all such as cannot be readily destroyed and replaced whenever they become soiled.

4. Keep a careful record of vaccinations, in which may be placed the following items: date of vaccination, name, age and sex of child, character and source of lymph used, number of insertions, result of inspection at end of a week, remarks, abnormal appearances, etc.

Record as "successful" only those cases in which a normal vesicle has been produced. In cases of revaccination record as successful only those cases in which either vesicles, normal or modified, or papules surrounded by areolæ, have resulted.

5. Use bovine lymph preferably. In times of epidemics of small-pox, and especially in cases where persons about to be vaccinated have been recently exposed to small-pox, the age of the lymph (time since it was taken from the animal) should be definitely ascertained, and in such cases recent lymph should always be employed in preference to that which is more than ten days old. If bovine lymph cannot be obtained and the lymph from a healthy infant taken on the seventh day after vaccination can be had, this may be used. Humanized lymph should never be taken

from cases of revaccination, but invariably from a primary case and from an infant in good health and of healthy parentage.

6. Keep in good condition the lancets or other instruments employed for vaccination and use them for no other purpose.

When vaccinating, have a clean napkin and a glass of water containing a disinfectant at your side, with which invariably cleanse the lancet after each operation before proceeding to another. Dipping the lancet in strong alcohol and immediately passing it through the flame of a lamp undoubtedly serves to sterilize it.

Never use an ivory point a second time either for the conveyance or for the storage of lymph, but when they have been put to their proper use, break or otherwise destroy them.

"The best results, on the whole, are those which follow the plan of scarification or abrasion." — *Seaton.*

The greatest care should be taken in performing the operation to secure aseptic conditions, in other words, absolute cleanliness. For this purpose the place of insertion, preferably the outer and anterior part of the arm from three to five inches below the bend of the shoulder, should be washed with soap and water and then wiped dry.

Scarify or lightly abrade the surface in at least two places about an inch apart, until the scarified spots appear slightly red and moist, but not enough to draw blood freely.

Moisten the ivory slips slightly at the points with pure water, and wipe off the lymph upon the scarified places, using at least two points for each person vaccinated.

Never use one point for two persons.

The after treatment: If any blood remains at the points of insertion it should be allowed to dry, and should not be washed off until the third morning after vaccination, when it may be removed by washing gently with a little pure warm water and a clean flannel or linen cloth. After this, a clean piece of soft linen may be sewed around the arm to prevent the sleeve from chafing the vesicles. This should be changed daily.

7. The vaccinator should in all cases require that each vaccinated person should appear at the end of a week for inspection, and especially in each case of primary vaccination, if the operation proves ineffectual, the vaccination should be repeated with fresh lymph.

Cases of Doubtful Diagnosis. — In all of the comparatively slight epidemics of small-pox which have occurred in recent years there has been a considerable number of cases in which the diagnosis, especially in the early stage of the disease, was more or less involved in doubt, and this was particularly true of those cases which occurred in the practice of young physicians who have entered upon practice since the epidemic of 1872–73.

Cases of measles, of chicken-pox, as well as some of the ordinary forms of skin diseases, have been mistaken for small-pox, while cases of genuine variola have been reported as chicken-pox, measles, etc. This fact is not to be wondered at when it is known that small-pox has been of such rare occurrence during the twenty years intervening between 1873 and 1893 that probably not one physician in a hundred in the State has met with a single case during that time.

In consequence of this fact it is desirable that any doubtful cases occurring in the practice of physicians who are not familiar with the natural history of the disease should be examined in consultation with a physician who has had experience in such cases. Much doubt and much annoyance to communities where such cases may occur may thus be avoided, and in some instances serious outbreaks may be prevented.

Other Infectious Diseases.

From such reports as have been received from local boards of health during 1893 it appears that the prevalence of diphtheria and typhoid fever has differed but little in severity from that of the previous year. The number of reported cases and deaths from each of these causes was but little greater for each disease.

From scarlet fever the reported cases and deaths were much larger in number than those of either 1891 or 1892.

From measles the cases and deaths were greater than those of 1891 and very largely in excess of those of 1892.

The statistics giving the number of reported cases and of reported deaths, together with the ratios of fatality, may be found at page 741, under the head of Health of Towns.

Many requests were received during the year for advice in regard to the management and control of infectious diseases, and visits were made to Provincetown, Newburyport, Ludlow, Somerville, Dalton, Hanover, Douglas, Falmouth, Rowley, Topsfield and other places for the purpose of investigating local outbreaks of typhoid fever, scarlet fever and diphtheria, and for affording such assistance to local boards of health as it was in the power of the State Board to give.

Notification of Infectious Diseases.

Among the different measures employed by sanitary authorities for the prevention of the spread of infectious diseases, the notification of the occurrence of such diseases now occupies a prominent place. Municipal authorities especially should have the requisite power everywhere to require immediate notice to be given them of every fresh outbreak of diseases dangerous to the public health in order that such authorities may take proper measures for the protection of the community.

The chief advantages of a system of notification lie in the possibility which is thus given to a local board of health to determine the extent of prevalence of an epidemic or a localized outbreak, and to inquire into the local causes which have operated to produce it. The board can then act intelligently in applying the proper remedies for preventing its further spread.

Laws enacted with this object in view have been in force in the older States for many years, but not until within the past ten or twenty years have pains been taken to execute such statutes with such degree of efficiency as to make them really protective. The law requiring the householder to report each case of dangerous disease to the local authority was enacted in Massachusetts in 1792, and that which requires the same duty on the part of the attending physician was enacted in 1827.

There can be no doubt that the law relative to notification has been productive of excellent results in the prevention of disease, especially in the cities and large towns. It has furnished the local boards of health with the necessary information relative to the origin of outbreaks of infectious disease, and in many instances enabled them to take timely steps for preventing its further spread. The law of 1884 requiring local boards to keep records upon this important matter has furnished information as to the prevalence of certain diseases in the principal cities and towns of the State, and has enabled school authorities to guard against the introduction and spread of contagious diseases in the public schools by means of the provision which requires the local board of health to notify the school committee of the occurrence of all cases of such contagious disease. In the smaller towns it is probable that instances of failure to comply with the provisions of the statute are much more frequent than they are in cities.

The statutes referred to in the foregoing comments are as follows: —

[PUBLIC STATUTES, CHAPTER 80, SECTION 78; ACTS OF 1884, CHAPTER 98, AND ACTS OF 1891, CHAPTER 188.]

(1.) When a householder knows that a person within his family is sick of small-pox, diphtheria, scarlet fever or any other disease dangerous to the public health, he shall immediately give notice thereof to the selectmen or board of health of the town in which he dwells, and upon the death, recovery or removal of such person, the rooms occupied and the articles used by him shall be disinfected by such householder in a manner approved by the board of health. Any person neglecting or refusing to comply with either of the above provisions shall forfeit a sum not exceeding one hundred dollars.

(2.) When a physician knows that a person whom he is called to visit is infected with small-pox, diphtheria, scarlet fever or any other disease dangerous to public health, he shall immediately give notice thereof in writing, over his own signature, to the selectmen or board of health of the town; and if he refuses or neglects to give such notice he shall forfeit for each offence not less than fifty nor more than two hundred dollars.

(3.) The boards of health in the several cities and towns shall cause a record to be kept of all reports received in pursuance of the preceding sections, and such record shall contain the names of all persons who are sick, the localities in which they live, the diseases with which they are affected, together with the date and the names of the persons reporting any such cases. The boards of health shall give the school committee immediate information of all cases of contagious diseases reported to them according to the provisions of this act.

(4.) The secretary of the Commonwealth shall furnish the boards of health with blank books for the record of cases of contagious diseases as above provided.

As an additional measure in the same direction the Legislature of 1893 enacted the following law, requiring that contagious diseases reported to the local boards of health shall, in turn, be reported by them to the State Board of Health: —

[CHAPTER 302 OF THE ACTS OF 1893.]

(1.) When the board of health of any city or town has had notice of the occurrence of a case of small-pox or any other disease dangerous to the public health in such city or town, such board of health shall, within twenty-four hours after the receipt of such notice, notify the State Board of Health of the same.

(2.) If the board of health of the city or town, in which a case of small-pox or any other disease dangerous to the public health has occurred,

refuses or neglects to send a notice as required in section one, such city or town shall forfeit its claim upon the Commonwealth for the payment of any expenses which may be incurred as provided in section eighty-three of chapter eighty of the Public Statutes.

This recent law went into effect in June, 1893, but very few returns in compliance with its provisions were received by the State Board of Health until after public notice had been given by the Board by means of a circular which was distributed to every Board of Health throughout the State.

As the "diseases dangerous to the public health" were not specified in the foregoing act, with the exception of small-pox, the Board deemed it desirable for the sake of securing uniform action on the part of local boards, that some definite expression of opinion should be made as to the meaning of the term "other diseases dangerous to the public health."

Hence, in the circular named above, the Board suggested that, in addition to *small-pox*, the following diseases shall be considered as dangerous to the public health within the meaning of the foregoing act: *scarlet fever, measles, typhoid fever, diphtheria, membranous croup, cholera, yellow fever, typhus fever, cerebro-spinal meningitis, hydrophobia, malignant pustule, leprosy and trichinosis.*

A supply of postal blanks was forwarded with the circular for the purpose of enabling local boards of health to comply with the terms of the act.

Various attempts have been made in England to enact a similar statute, but these efforts were unsuccessful until 1889. By the terms of the law then enacted the notification of infectious diseases to the sanitary authority was made compulsory throughout London, while the principle of local option was applied to all other districts.

During the year in which this bill was under consideration by Parliament, intense opposition had been manifested by many of the members of the medical profession throughout England. Objections were offered not only by the people, but also by the medical profession, but the bill passed and finally became a law.

The fallacy of the objections has been abundantly proven by the three years' experience of the towns of England where the Notification Act has been adopted. The notification of each case is made by a certificate furnished by the attending physician, for which a fee of two shillings and sixpence is paid, except in a case where the person

giving the certificate is the medical officer of a public institution, when the fee is one shilling.

The diseases to which this act applies are small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlet-fever, typhus, typhoid and puerperal fevers, and any other infectious disease which may be added to this list by the sanitary authority of a district.

Up to the year 1892, the act had been adopted in 1,051 districts, having an aggregate population of nearly sixteen millions, to which should be added the population of London and fifty towns in which local acts made it compulsory, making in all a population of 24,012,399 over which the act was in force, out of a total of 29,001,018. In a few towns the sanitary authorities had availed themselves of the power to require notification in the case of measles, rötheln, chickenpox and hydrophobia.

Further information as to the details of the operation of the statute of 1893 may be found upon page 639.

Offensive Trades.

Under the provisions of the acts relating to noxious and offensive trades the State Board of Health is authorized to hear parties making complaints, and when "in the judgment of the Board the public health or the public comfort and convenience require, the Board may order any person to desist and cease from further carrying on said trades or occupations." No applications under this act were received during the year, but visits and inspections were made at the request of local boards of health in two instances, where rendering works were being conducted.

The Board's Exhibit at the Columbian Exposition (1893).

The subject of public hygiene was represented at the Columbian Exposition at Chicago by exhibitions of the work of State and local boards of health. The exhibits of this important department of public work were installed in the Anthropological Building, in the south part of Jackson Park. Of these exhibits none created greater or more favorable comment than that of the State Board of Health of Massachusetts.

It is proper that some account of the exhibition should be made a matter of public record in this report of work for the year 1893.

A communication was received Sept. 24, 1892, from the superintendent of the Bureau of Hygiene and Sanitation of the Department

of Liberal Arts of the Columbian Exposition, calling the attention of the Board to the opportunity that would be given at the Fair for placing before the public the work of State boards of health in the prevention of infectious diseases, and at the same time asking whether the Board desired to be represented at the Exposition.

At a later date (Dec. 28, 1892) further information was received upon the subject, together with a blank form of application for allotment of space in which to install the exhibit of the Board.

At the next meeting of the Board (January, 1893) it was voted to ask for 1,200 square feet of space for the Board's exhibit.

The Board was informed that, in consequence of the fact that only 10,000 feet could be devoted to the whole subject of hygiene and sanitation in the United States, it would be impossible to afford an eighth of it to the State of Massachusetts. It was therefore finally decided to grant the Board 500 feet of space for its purpose. To this space were ultimately added 120 square feet.

An appropriation had already been provided by the Legislature to defray the expenses of such representations as might be made at the Exposition by different departments of the State government, and the sum of $4,000 was set aside for the exhibit of the State Board of Health. The Board then directed that an exhibit should be prepared representing the progress of public hygiene in the State.

The exhibit consisted of the following items: —

General Sanitary Work of the Board.

Complete set of reports of State Board of Health from 1869 to 1891.

Special reports of the Board, circulars upon infectious diseases and other health topics, sets of blank forms and manual of health laws.

Reports of city boards of health of Massachusetts for the year 1892.

Charts and Diagrams illustrating the Following Subjects.

The death-rate of Massachusetts for a series of years.

Effect of density of population on the general death rate.

Effect of density of population on the death rate from each of the following diseases (for twenty years, 1871–90): Measles, scarlet fever, diphtheria, small-pox, typhoid fever, cholera infantum, consumption and pneumonia.

Improvement in registration.

Decline in death rates from certain causes.

Seasonal mortality in Massachusetts.

Geographical Distribution of Eight Diseases.

Eight maps showing the comparative mortality from measles, scarlet fever, diphtheria, small-pox, typhoid fever, cholera infantum, phthisis and pneumonia.

Diagrams and maps illustrating epidemics of typhoid fever in Springfield and Lowell.

Engineering Department (Water Supply and Sewerage).

Model of Lawrence Experiment Station, carefully constructed of wood and iron painted, and in a scale of one-half inch to the foot.

Sand sieve.

Steam sterilizer.

Thermostat.

Galvanized-iron filter.

Complete battery of stills.

Sections of sand filters, in glass tubes.

Apparatus for determining the color of waters.

Bacteria stand, with tubes.

Sets of double dishes.

Large map of Massachusetts showing the normal chlorine of different regions.

Small map of Massachusetts showing the normal chlorine of different regions.

Water-shed map of Massachusetts.

Lower basin of Merrimack River (blue print).

Temperature chart.

Chart showing advice to cities and towns, water supplies.

Chart showing advice to cities and towns, sewage disposal.

Chart showing average of water analyses.

Map of North Metropolitan Sewerage System.

Map of Lawrence city filter.

Photographs of Framingham sewage beds.

 Pumping station.

 Applying sewage. (2 photographs.)

 Cornfield treated with sewage.

Photographs of Marlborough sewage beds.

 Gate-house.

 Underdrains.

 Filter-bed.

 Filter-beds after harrowing.

Room 36, Massachusetts Institute of Technology (Laboratory of State Board of Health). (2 photographs.)

Lawrence Experiment Station. (3 photographs.)

Photographs of bacteria cultures.

City water of Lawrence and Tank 8.

Tanks 1, 2, 6 and 13.

Forty one-gallon bottles, containing: —

Samples of sewage applied to each of the filters at Lawrence, Framingham, etc.

Samples of effluents from sewage-filters at Lawrence, Framingham, etc.

Samples of sewage containing dyes (with water before and after filtration).

Samples of Merrimack River water before and after filtration.

Samples of surface and ground waters from rivers, ponds, reservoirs, wells, springs, etc. (pure and polluted).

Series of eight-ounce bottles containing samples of filtering materials, sand, gravel, etc.

Department of Food and Drug Inspection.

Charts showing ratio of adulteration of milk in Massachusetts.

Charts showing ratio of adulteration of other kinds of food.

Charts showing ratio of adulteration of spices.

Chart showing decrease in ratio of hogs infected with trichinæ under improved modes of feeding.

Chart showing ratio of expenditure for food, clothing, rent, fuel, etc., in different countries.

Micro-photographs of pure articles of food: coffee, pepper, mustard, cloves, ginger, etc.

Micro-photographs of the same when adulterated.

Samples of pure foods, in glass bottles.

Samples of adulterants used in the foregoing, as sold commercially for the purpose of adulteration.

Models of trichinæ, free (male and female) and encysted.

Information was received that the Anthropological Building would be ready for the reception of exhibits by the 12th of April.

The material was collected at the building of the Mechanics' Charitable Association in Boston, and was boxed, ready for shipment, in fifty-four packages, and left Boston on April 10. It arrived at the Fair grounds in good condition on April 12, but the building was then in no condition to receive it, and it was therefore stored near by until the building could be completed. The roof was not put on till April 29.

Prof. W. T. Sedgwick was given charge of installing the exhibit, and went to Chicago for that purpose. He obtained the services of attendants, so that some one was in charge of the exhibit from the outset to the close of the Exposition, a fact which contributed very largely to its success.

In commenting upon this exhibit, Mr. E. C. Hovey, secretary and executive officer of the Massachusetts commission at the Fair, says: —

Two exhibits alone were well-nigh worth the entire sum expended by the Commonwealth on her contributions to these important departments. The exhibits of the Massachusetts State Board of Health and the Rumford Kitchen were *sui generis*, and told to the world in a most striking manner their story of patient investigation and continued research. Through the auspices of the State Board of Health there was installed an exhibit which, in a most complete and graphic manner, laid before the visitor the work which has been accomplished in the State in dealing with the problems of health as dependent upon sanitation. Here also was to be seen a model of the Experiment Station in Lawrence, which it may be truly said has not its equal in the country. The important investigations made by the Board of Health, looking to the prevention of the adulteration of food, were effectively shown, and the walls were covered with charts and statistics which served to demonstrate the nature of the researches made by the Board, researches which have had, and will continue to have, marked influence on the health of the citizens of the Commonwealth.*

Many thousands of visitors viewed the exhibit of the Board during the continuance of the Fair, and especially during the week of the congress of public hygiene. The Board published a large edition of a guide or prospectus of the exhibit, which was distributed free to all visitors. The exhibit also received very favorable comment in the various medical and sanitary periodicals, not only in the United States but also in foreign countries.

The following notice of award has been received by the Board: —

UNITED STATES.

DEPARTMENT OF LIBERAL ARTS.

Exhibitor. — State Board of Health. *Group 147.* — Class 833.
Address. — Boston, Mass. *Exhibit.* — Maps, Charts and Models.

AWARD.

For exhaustive examinations and reports upon the public water supplies of the State; the relation of water supply to the public health, resulting in a definite knowledge as to the ways in which certain diseases are disseminated; and the best methods of protecting the purity of waters used for

* New England Magazine, February, 1894. Article by Commissioner E. C. Hovey.

domestic purposes, thereby diminishing the prevalence of water-carried diseases.

For the practical application of the experimental methods to the operation of sewerage and sewage disposal.

For the construction of a filter for the removal of the germs of diseases from the polluted water supply of a city.

For an important, instructive and accurate series of statistical charts showing the distribution of diseases throughout the State.

For important investigations in regard to food adulteration.

(Signed) JOHN H. RAUCH,
Individual Judge.

Approved: DR. K. BUENZ,
President Departmental Committee.

Approved: JOHN BOYD THACHER,
Chairman Executive Committee on Awards.

Date: Feb. 28, 1894.

Expenses of the Exhibit.

The expenses of this exhibit were as follows, a special appropriation having been generously provided by the Legislature, for this exhibit as well as for those of other State departments: —

Labor and cost of materials in preparing the exhibit,	$1,514 92
Boxing and packing exhibit,	55 44
Transportation,	180 05
Installation,	1,026 89
Attendance,	1,128 80
Janitor service,	98 50
	$4,004 60

MANUAL OF HEALTH LAWS.

The Board has published, at intervals of four years, since 1882, a manual for the use of boards of health, containing all of the laws relating to public health which have been enacted up to the date of publication, together with such decisions of the supreme court as have been made upon the same subject.

Compilations of this character have been issued in 1882, 1886 and 1890. The edition of 1890 having become exhausted the Board authorized the publication of a new edition, which was prepared by the secretary, with the advice of Mr. Tobey.

The manual has become an indispensable aid to local boards of health, since it obviates the necessity of owning not only a copy of

the Public Statutes (edition of 1882) but also of each of the Blue Books containing the acts and resolves of each successive year since 1882. Copies of the Manual have been furnished to each of the local boards of health throughout the State, to the public health committee of the Legislature, and to other persons interested in public hygiene. The book contains about 200 pages, with a very full index. It has the laws relating to the public health, including those which pertain to the inspection of food and drugs, the registration of vital statistics and the medical examiners' laws.

Cremation.

Under the provisions of chapter 265 of the Acts of 1885 the Legislature authorized the formation of corporations for the purpose of incinerating the bodies of the dead.

By the terms of this act it was provided that —

Every such corporation may acquire by gift, devise or purchase, and hold in fee simple so much real estate not exceeding in value fifty thousand dollars as may be necessary for carrying out the objects connected with and appropriate to the purposes of said corporation, and situated in such place as the state board of health may determine to be suitable for said objects and purposes. No building shall be erected, occupied or used by such corporation until the location and plans thereof, with all details of construction, have been submitted to and approved by said board or some person designated by it to examine them.

Every such corporation may make by-laws and regulations consistent with law and subject to the approval of said state board, for the reception and cremation of bodies of deceased persons, and for the disposition of the ashes remaining therefrom.

Further provision was made in the same act to prevent the concealment of crime in the case of cremated bodies.

Acting under the provisions of this act the Massachusetts Cremation Society applied to the Board April 3, 1893, requesting its approval of a location for a crematory in the city of Boston, the location being a tract of nearly two acres on the north-west side of Walk Hill Street, near the Forest Hills Cemetery.

The Board, after viewing the premises, approved the location. Subsequently, the plans and method of cremation were submitted to the Board, and after examination by a competent engineer these also were approved, together with certain regulations adopted by

the society. The regulations approved by the Board were as follows: —

Every dead body received for cremation must, if the death occurred in Massachusetts, Rhode Island, or Connecticut, be accompanied by the usual burial permit required by law before burial, and by certificate from the medical examiner of the district within which the death occurred, that he has viewed the body and made personal inquiry into the cause and manner of death, and is of opinion that no further examination or judicial inquiry concerning the same is necessary. Dead bodies received from states other than those above mentioned must be accompanied by the certificates of two physicians (each of whom must be a graduate of some legally organized medical college, and one of whom shall have been the attending physician of the deceased), setting forth the cause of death and the opinion that no further examination or judicial inquiry concerning the same is necessary.

The crematory was completed and ready for the reception of bodies for incineration in December, and the first cremation took place on December 30, 1893. From that date up to the present time (May, 1894) the whole number of bodies cremated was thirty-one, of which number sixteen were males and fifteen were females.

Food and Drug Inspection.

The work of the Board in this department has progressed uniformly during the year, attention being paid to the inspection of all articles which properly come within the provisions of the food and drug acts, as offered for sale in the different cities and towns throughout the State.

Special attention has been given to the examination of the methods of food inspection as practised in other countries, with the view of improving our own where improvement is possible.

In the examination of reports of food inspection of other countries it appears that the general ratio of adulteration is usually less than that of Massachusetts, a fact which requires explanation, since the difference is apparent and not real. The law in this Commonwealth requires that three-fifths of the appropriation shall be expended in the inspection of milk and milk products, consequently a large portion of the samples taken for examination are samples of milk. The legal standard of milk is high as compared with that of other countries. In most countries this standard (when a standard is adopted) is 11½

per cent. of total solids, while in Massachusetts the standard is 13 per cent., except in May and June, when it is 12 per cent.

Between these two limits of 12 and 13 per cent. a considerable percentage of milk is produced by cows. The effect of this annual change of standard for two months of the year shows itself in a very marked degree upon the ratio of adulteration, that is to say of legal adulteration or departure from the standard as defined by law. During the two months of May and June the ratio of samples of milk found to be below the legal standard of 12 is often as low as 12 or 15 per cent. of the whole, while in the other ten months it often rises to 40 and even to 50 per cent. and higher, since a very considerable part of all the samples range between these two points, 12 and 13 per cent. of solids.

In the report of the analyst may be found the results of the work accomplished during the year in this direction. In addition to the usual routine work a special analysis of bread and of cheese was made, the results of which are published in the analyst's report.

The total number of samples of articles of food and drugs which were examined during the year was 6,409.

The number of prosecutions conducted was 96, and the amount of fines collected and paid into the local treasuries was $2,476.

The efficiency of the work accomplished by the Board in this department has been frequently acknowledged by the authorities of other States, as well as by the dealers in food supplies in our own State.

The actual economic value of this continuous work to the State has been already mentioned in previous reports. It is sufficient to say that the advantages gained far outweigh the cost of enforcing the statutes.

REGISTRATION OF VITAL STATISTICS.

In the following summary of the vital statistics of the State for the year 1892, the estimate of population employed as a basis is made upon the same plan as that of the previous year, namely, the geometric rate of increase. Upon this basis the estimate of population for the year 1892 is 2,369,993.

There were 22,507 marriages, 65,824 living births, 2,293 still-births and 48,762 deaths registered in Massachusetts in 1892.

The ratios to the estimated living population were as follows: —

Marriage rate,	9.50	per 1,000 of the living population.
Persons married,	18.99	" " " " "
Birth rate,	27.77	" " " " "
Death rate,	20.57	" " " " "
Excess of birth rate over death rate,	7.20	" " " " "

International Vital Statistics.

In the following summary are presented the marriage, birth and death rates of the six New England States and those of the principal countries of Europe having registration for a period of twenty years (1871–90) and for the years 1891 and 1892. The first year of registration of Maine completes the list of the New England States for the year 1892.

The six New England States embrace a population of about five millions, and the entire population of the countries embraced in this summary numbers about two hundred and twenty-five millions.

Summary of the Vital Statistics of the Principal Countries of Europe for Twenty Years, and for 1891 and 1892, together with those of the New England States.

STATES AND COUNTRIES.	Twenty Years — 1871-1890.				1891.				1892.			
	Marriage Rate.	Birth Rate.	Death Rate.	Excess of Birth Rate over Death Rate.	Marriage Rate.	Birth Rate.	Death Rate.	Excess of Birth Rate over Death Rate.	Marriage Rate.	Birth Rate.	Death Rate.	Excess of Birth Rate over Death Rate.
Massachusetts,	18.1	25.7	19.7	6.0	18.9	27.4	19.7	7.8	19.0	27.8	20.6	7.2
Maine,	-	-	-	-	-	-	-	-	17.1	21.2	18.4	2.8
New Hampshire,	18.6	18.0*	18.9	-	20.6	19.8*	19.3	-	21.6	20.6*	21.2	-
Vermont,	15.6	20.2	15.1	5.1	17.0	20.0	16.9	3.1	17.5	19.7	18.6	1.1
Rhode Island,	18.7	23.7	18.0	5.7	18.8	25.9	18.7	7.2	19.4	24.7	20.5	4.2
Connecticut,	16.0	23.6	17.1	6.5	16.8	24.8	19.2	5.6	16.6	24.7	19.0	5.7
England and Wales,	15.6	34.0	20.3	13.7	15.6	31.4	20.2	11.2	15.4	30.5	19.0	11.5
Scotland,	13.9	33.6	20.4	13.2	13.9	31.2	20.7	10.5	14.1	30.7	18.5	12.2
Ireland,	9.0	24.9	18.0	6.9	9.2	23.1	18.4	4.7	9.3	22.4	19.4	3.0
Italy,	15.6	37.3	28.6	8.7	15.0	37.3	26.2	11.1	15.0	36.3	26.2	10.1
Denmark,	15.2	31.7	19.0	12.7	13.6	31.0	20.0	11.0	13.6	29.5	19.4	10.1
Norway,	13.7	30.7	16.9	13.8	13.2	30.9	17.5	13.4	12.6	29.6	17.7	11.9
Sweden,	13.1	29.8	17.6	12.2	11.6	28.3	16.8	11.5	-	-	-	-
Austria,	16.3	38.6	30.6	8.0	15.4	38.1	27.9	10.2	15.6	36.2	28.8	7.4
Hungary,†	19.1	44.0	33.7	10.3	17.2	42.3	33.1	9.2	-	-	-	-
Switzerland,	14.7	29.4	22.1	7.3	14.3	28.2	20.7	7.5	14.7	28.0	19.3	8.7
German Empire,‡	16.4	38.1	26.0	12.1	16.1	37.0	23.4	13.6	15.9	35.7	24.1	11.6
Holland,	15.1	35.2	22.6	12.6	14.2	33.7	20.7	13.0	14.4	32.0	21.0	11.0
Belgium,	14.2	31.0	21.4	9.6	14.8	29.6	21.0	8.6	15.4	28.9	21.8	7.1
France,	15.4	24.6	22.8	1.8	15.0	22.6	22.6	0.0	15.2	22.1	22.6	—0.5§

* Seven years. Registration of births said to be defective. † Fifteen years. ‡ Nineteen years. § Excess of death rate.

Marriages.

The number of marriages (22,507) was greater than that of any previous year. The greatest number occurred in November (2,716) and the least number in March (1,037).

The marriage rate was 18.99, and was higher than that of any year since 1887, when it was 19.0. The estimated marriage rate of the decennial period ending with 1892 was 18.61.

Births.

The number of living births registered in Massachusetts during the year 1892 was 65,824, and the birth rate, as calculated upon an estimated population of 2,369,993, was 27.77 per 1,000 of the living population. This was the highest birth rate of any year since 1874, when it was 28.32. The lowest birth rate in the intervening period was that of 1879, which was 22.94. The estimated birth rate of the decennial period ending with 1892 was 26.08.

The ratio of males to females among living births where the sex was stated was 105.6 females to each 100 males.

The greatest number of births occurred in December and the least number in February.

There were 990 illegitimate births registered, or 15 per 1,000 of the living births registered during the year, as compared with 1,078, or 17.1 per 1,000 in 1891.

The births in the thirty cities were 46,597, as compared with 43,828 in 1891, an increase of 6.3 per cent. Those in the remainder of the State were 19,227, as compared with 19,176 in 1891, an increase of less than three-tenths of 1 per cent.

Deaths.

The number of deaths (48,762) was greater than that of any previous year. The death rate (20.57 per 1,000) was higher than that of any previous year since 1875. The estimated death rate of the decennial period ending with 1892 was 19.64.

Infant Mortality. — The number of deaths of infants under one year old was 10,649, or 21.84 of the total mortality, which was less than that of either 1891 or 1890, and was also greater than the mean of the twenty-year period (1873–92).

The deaths of children under five were 15,225, or 31.22 per cent. of the total mortality, which was less than that of any year for the

past twenty years except that of 1882, which was nearly identical with it.

As compared with the births, the mortality of infants under one was 16.18 per cent. of the living births, which was slightly greater than that of 1891, and also greater than the mean of the twenty-year period (1873–92).

The deaths of centenarians reported in 1892 were thirteen in number, nine of whom were women, and ten were of foreign birth. Of the three women who were of native birth, one died in her native town, and each of the others in a town adjoining her native town.

Sex. — The deaths of males were 24,643 and those of females 24,119. But, by the census of 1890, the females were largely in excess of the males, in the ratio of 51.42 per cent. of the former to 48.58 of the latter (nearly). If the same ratio prevailed in 1892, the death rate of males was 21.40 per 1,000, and that of females 19.79, these ratios being in each case higher than those of the census year 1890, and also higher than the mean of the seven census years, 1860, '65, '70, '75, '80, '85, '90.

Stating this more clearly, the deaths of males to 1,000 deaths of females in equal numbers living were 1,059 in 1890, while in 1892, the difference in population of the two sexes being estimated in the same ratio, the deaths of males to 1,000 females in equal numbers living were 1,081. In England, for 1891, the deaths of males to 1,000 deaths of females were 1,128, and for the ten-year period (1881–90) they were 1,123.

Causes of Death.

The number of deaths, the causes of which were not registered in 1892, was 470, or .96 of 1 per cent. of the mortality from all causes. This ratio was smaller than that of any previous year since the beginning of registration, except that of 1891, which was .9 of 1 per cent.

The average of the ten years ending with 1892 was 1.23 per cent. of the total mortality of the period.

The sanitary significance of a table in which is presented the ratio of deaths from specified causes, or groups of causes, to the living population, must be acknowledged, as compared with the older method of comparison with the total mortality. Hence the following table is introduced, in which are presented the deaths from each group of causes, together with the rate per million living for each

group for 1892, and the rate per million for each year of the period (1883–92).

The practical value of international vital statistics becomes more apparent every year. An impetus has been given to such work by the labors of the International Statistical Institute, which convened at Chicago in 1893.

For the sake of comparison the column of means for the ten-year period (1881–90) for England has been added to the following table from the Fifty-fourth Report of the Registrar General of England for 1891.

The deaths from the group of infectious diseases in Massachusetts in 1892 were greater than the mean for the ten-year period (1883–92).

The deaths from the group of constitutional diseases in 1892 were less than those of the ten-year period.

The deaths from the developmental group of causes were slightly less than those of the decade.

The deaths from local diseases have increased from a rate of 7,572 per million in 1884 to 9,651 per million in 1892. The mean ratio for the period was 8,496.

The deaths from violence have not varied very greatly, the extremes being 894 per million in 1883, and 748 in 1884, while the mean was 815.

The deaths from ill-defined and unspecified causes have generally diminished from a maximum of 357 per million in 1883 to a minimum of 176 in 1891, the mean being 242.

The lower line may be read as a general death rate per million, or per thousand of the population, as convenience may dictate, in the latter case the comma being used as a decimal point.

CAUSES OF DEATH.	Total Deaths, 1892.	Rate per Million Living.										Massachusetts.	England.
		1892.	1891.	1890.	1889.	1888.	1887.	1886.	1885.	1884.	1883.	Mean, 1883-92.	Mean, 1881-90.
Infectious diseases,	9,248	3,903	3,587	3,607	3,692	3,802	3,866	3,414	3,674	4,022	4,070	3,759	2,753
Constitutional diseases,	9,822	3,934	3,923	4,110	4,136	4,334	4,429	4,464	4,594	4,548	4,694	4,296	3,325
Developmental diseases,	4,770	2,018	2,005	1,963	2,009	2,024	2,094	2,027	2,065	2,100	2,172	2,043	1,598
Local diseases,	22,871	9,651	9,117	8,714	8,352	8,702	8,382	7,738	8,277	7,572	7,921	8,496	9,785
Violence,	2,081	878	804	810	778	787	827	771	748	852	894	815	651
Ill-defined and not specified causes,	470	198	176	231	225	253	242	225	257	280	357	242	1,042
Deaths from all causes,	48,762	-	-	-	-	-	-	-	-	-	-	-	-
Rate per million inhabitants,	-	20,577	19,612	19,435	19,192	19,902	19,840	18,639	19,615	19,374	20,108	19,651	19,149

Still-births are not embraced in this table.

STATISTICS OF CERTAIN DISEASES, MASSACHUSETTS, 1873–92.

Deaths, and Ratios compared with Population and Mortality from All Causes.

	Small-pox.			Measles.			Scarlet Fever.			Diphtheria and Croup.			Typhoid Fever.			Cholera Infantum.			Consumption.		
	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.
1873, ...	668	4.3	1.97	180	1.1	.53	1,472	9.4	4.34	745	4.7	2.20	1,406	8.9	4.15	2,553	16.2	7.53	5,556	35.3	16.38
1874, ...	26	.2	.08	161	1.0	.50	1,382	8.6	4.33	918	5.6	2.86	1,147	7.1	3.6	2,322	14.4	7.28	5,284	32.8	16.57
1875, ...	34	.2	.09	233	1.4	.67	1,684	10.2	4.81	1,880	11.4	5.31	1,059	6.4	3.02	2,606	15.8	7.45	5,738	34.7	16.40
1876, ...	31	.2	.09	47	.3	.14	1,222	7.3	3.68	3,294	19.6	9.92	881	5.3	2.65	2,087	12.4	6.29	5,327	32.2	16.05
1877, ...	24	.14	.08	135	.8	.44	467	2.7	1.49	3,178	18.7	10.14	814	4.8	2.59	1,927	11.3	6.15	5,457	32.0	17.41
1878, ...	2	.01	.01	305	1.8	.97	404	2.2	1.29	2,517	14.6	8.04	679	3.9	2.16	1,573	9.1	5.02	5,334	30.8	17.04
1879, ...	7	.04	.02	19	.1	.06	850	4.8	2.67	2,293	13.1	7.21	637	3.6	2.00	1,349	7.7	4.24	5,223	29.7	16.42
1880, ...	38	.21	.11	236	1.3	.67	574	3.2	1.63	2,394	13.4	6.78	882	4.9	2.50	2,118	11.9	6.00	5,494	30.8	15.57
1881, ...	47	.25	.13	230	1.3	.63	397	2.2	1.09	2,383	13.1	6.54	1,072	5.9	2.94	1,861	10.3	5.10	5,886	32.4	16.14
1882, ...	45	.24	.12	68	.4	.18	318	1.7	.86	1,771	9.6	4.81	1,079	5.8	2.93	2,159	11.7	5.87	5,865	31.8	15.93
1883, ...	5	.03	.01	321	1.7	.85	575	3.1	1.52	1,621	8.6	4.29	860	4.6	2.28	1,941	10.3	5.14	5,931	31.6	15.71
1884, ...	3	.01	.01	75	.4	.20	627	3.3	1.69	1,646	8.6	4.45	875	4.6	2.36	2,081	10.9	5.62	5,798	30.4	15.67
1885, ...	19	.10	.05	313	1.6	.82	587	3.0	1.54	1,523	7.8	3.98	768	3.9	2.02	1,852	9.5	4.86	5,955	30.7	15.63
1886, ...	-	-	-	130	.6	.35	331	1.7	.89	1,558	7.8	4.18	800	4.0	2.15	1,931	9.7	5.18	5,897	29.5	15.83
1887, ...	3	.01	.007	455	2.2	1.12	594	2.9	1.46	1,628	7.9	3.99	922	4.5	2.26	2,131	10.4	5.23	5,871	28.6	14.40
1888, ...	8	.04	.02	219	1.0	.52	504	2.4	1.20	1,831	8.7	4.35	943	4.5	2.24	2,195	10.4	5.21	5,728	27.1	13.61
1889, ...	6	.03	.01	171	.8	.41	185	.8	.44	2,214	10.2	5.30	891	4.1	2.13	2,156	9.9	5.16	5,581	25.7	13.36
1890, ...	1	.004	.002	114	.5	.26	196	.9	.45	1,626	7.3	3.74	835	3.7	1.92	2,491	11.1	5.72	5,791	25.9	13.31
1891, ...	1	.004	.002	236	1.0	.52	246	1.1	.54	1,218	5.3	2.69	821	3.6	1.82	2,771	12.0	6.13	5,484	23.8	12.14
1892, ...	2	.01	.004	88	.4	.18	669	2.8	1.37	1,465	6.1	2.98	827	3.5	1.69	2,898	12.2	5.94	5,739	24.2	11.77

STATISTICS OF CERTAIN DISEASES, MASSACHUSETTS, 1873-92 — Concluded.

Deaths, and Ratios compared with Population and Mortality from All Causes — Concluded.

	PNEUMONIA.			WHOOPING-COUGH.						KIDNEY DISEASES.			HEART DISEASES.			BRAIN DISEASES.		
	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.	Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.				Deaths.	Death Rate per 10,000 Living.	Percentage of Total Mortality.			Percentage of Total Mortality.			Percentage of Total Mortality.
1873,	2,007	13.3	6.18	264	1.7	.78				460	2.9	1.35	1,236	7.9	3.64	2,651	16.9	7.83
1874,	2,386	14.8	7.49	440	2.6	1.41				463	2.9	1.45	1,272	7.9	3.99	2,545	16.8	7.98
1875,	2,940	17.3	8.40	242	1.5	.69				509	3.1	1.45	1,331	8.1	3.80	2,715	16.4	7.76
1876,	2,447	14.6	7.37	192	1.1	.58				486	2.9	1.47	1,335	8.0	4.02	2,627	15.7	7.92
1877,	1,972	11.6	6.29	369	2.2	1.18				535	3.1	1.71	1,365	7.9	4.32	2,649	15.5	8.44
1878,	2,171	12.6	6.93	400	2.3	1.28				615	3.6	1.96	1,442	8.4	4.61	2,909	16.8	9.29
1879,	2,647	15.0	8.32	302	1.7	.95				693	3.9	2.18	1,515	8.6	4.76	2,946	16.8	9.26
1880,	3,076	17.2	9.71	230	1.3	.65				696	3.9	1.98	1,728	9.7	4.89	3,364	18.8	9.58
1881,	2,967	16.4	8.14	217	1.2	.59				825	4.5	2.27	1,937	10.7	5.31	3,355	18.5	9.20
1882,	2,932	15.9	7.97	265	1.4	.72	[illegible]	[illegible]	[illegible]	877	4.7	2.38	2,025	11.0	5.50	3,393	18.4	9.22
1883,	3,045	16.2	8.07	137	.7	.36	1,026	5.5	2.72	959	5.1	2.54	2,153	11.5	5.70	3,562	19.0	9.44
1884,	2,646	13.7	7.15	410	2.1	1.11	1,060	5.6	2.86	1,000	5.2	2.70	2,117	11.1	5.72	3,669	19.2	9.92
1885,	3,468	17.9	9.10	164	.9	.48	1,067	5.6	2.65	1,088	5.6	2.86	2,227	11.5	5.85	3,894	20.0	10.22
1886,	2,836	14.2	7.61	271	1.4	.73	1,104	5.5	2.96	1,135	5.7	3.05	2,325	11.6	6.24	3,844	19.2	10.32
1887,	3,348	16.3	8.21	232	1.1	.57	1,174	5.7	2.86	1,120	5.4	2.75	2,690	13.1	6.60	4,257	20.7	10.44
1888,	3,716	17.6	8.83	245	1.2	.58	1,275	6.0	3.03	1,318	6.2	3.13	3,061	14.6	7.27	4,522	21.4	10.74
1889,	3,440	15.8	8.23	310	1.4	.74	1,325	6.1	3.17	1,256	5.8	3.01	3,280	14.2	7.85	4,313	19.8	10.32
1890,	4,038	18.0	9.28	363	1.6	.83	1,357	6.2	3.19	1,273	5.7	2.92	3,417	15.3	7.85	4,389	19.6	10.08
1891,	4,337	18.8	9.60	219	.9	.48	1,395	6.1	3.09	1,474	6.4	3.26	3,502	15.6	7.95	4,711	20.5	10.42
1892,	5,020	21.2	10.29	248	1.0	.61	1,402	5.9	2.87	1,585	6.5	3.15	3,733	15.7	7.65	5,036	21.2	10.38

In the last two tables are presented the numbers of deaths, the death rates per 10,000 of the living population and the percentage of the total mortality for each of the twenty years ending with 1892 and for each of thirteen prominent causes and groups of causes of death.

Small-pox. — The number of deaths from small-pox during the year was 2, as compared with 1 in 1891, 1 in 1890, 4 in 1889 and 8 in 1888.

Compared with the estimated living population the death rate from this cause was only .01 of 1 per 10,000 and the percentage of the total mortality was only .004 of 1 per cent. (Further information relative to the prevalence of small-pox will be found under the head of infectious diseases, page viii.)

Measles. — The number of deaths from measles in 1892 was 88, as compared with 236 in 1891 and 114 in 1890. The death rate per 10,000 of the estimated population from this cause was .4 and the percentage of the total mortality was .18.

The number of deaths from this cause was less than that of any year since 1884, when it was 75. The minimum death rate from this cause for the twenty-year period was .1 per 10,000 in 1879, and the maximum was 2.2 in 1887.

Scarlet Fever. — The number of deaths from scarlet fever in 1892 was 669, as compared with 246 in 1891 and 196 in 1890 and was the greatest number in any year since 1879.

The death rate per 10,000 of the estimated population from this cause was 2.8 and the percentage of the total mortality 1.37.

The minimum death rate from this cause for the twenty-year period (1873–92) was .8 per 10,000 in 1889, and the maximum was 10.2 in 1875.

Diphtheria and Croup. — The number of deaths from diphtheria and croup in 1892 was 1,455 as compared with 1,218 in 1891 and 1,626 in 1890.

The death rate per 10,000 of the estimated living population was 6.1 and the percentage of the total mortality was 2.98.

The minimum death rate from these causes for the twenty-year period ending with 1892 was 4.7 per 10,000 in 1873, and the maximum was 19.6 in 1876.

The mean death rate from these causes for the first half of the twenty-year period was much greater than that of the last half.

Typhoid Fever.—The number of deaths from this cause in 1892 was 827, as compared with 821 in 1891 and 835 in 1890.

The death rate from this cause per 10,000 of the estimated population was 3.5 and the percentage of the total mortality was 1.69.

The minimum death rate for the twenty-year period ending with 1892 was 3.5 per 10,000 in 1892, and the maximum was 8.9 in 1873.

The mean death rate from this cause for the first half of the twenty-year period was considerably greater than that of the last half.

Cholera Infantum.—The number of deaths from cholera infantum in 1892 was 2,898, as compared with 2,771 in 1891 and 2,491 in 1890.

The death rate from this cause per 10,000 of the population was 12.2 and the percentage of the total mortality was 5.94.

The minimum death rate from cholera infantum in the twenty-year period was 7.7 per 10,000 of the estimated population in 1879, and the maximum was 16.2 in 1873, the first year of the period. In the previous year (1872) however, the death rate from this cause was higher than that of any year of registration either before or since that date.

Consumption.—The number of deaths from this disease in 1892 was 5,739, as compared with 5,484 in 1891 and 5,791 in 1890.

The death rate per 10,000 of the estimated population from this cause was 24.2 and the percentage of the total mortality 11.77.

The minimum death rate from this cause for the twenty-year period ending with 1892 was 23.8 per 10,000 in 1891, and the maximum was 35.3 in 1873, the first year of the period.

In comparing the two ten-year periods 1873–82 and 1883–92, there is found to be a very marked decrease in the mean death rate of the latter as compared with that of the former.

Pneumonia.—The deaths from pneumonia were 5,020, as compared with 4,337 in 1891 and 4,038 in 1890.

The death rate from this cause per 10,000 of the estimated population was 21.2 and the percentage of the total mortality 10.29.

The minimum death rate from pneumonia for the twenty-year period (1873–92) was 11.6 per 10,000 in 1877 and the maximum was 21.2. The increase in the death rate from pneumonia during the twenty-year period was greater than the decrease in the death rate from consumption.

Whooping-cough. — The deaths from whooping-cough in 1892 were 248, as compared with 219 in 1891 and 363 in 1890.

The death rate per 10,000 of the estimated population from this cause was 1 and the percentage of the total mortality was .51 of 1 per cent.

The minimum death rate of the twenty-year period ending with 1892 was .7 per 10,000 in 1883 and the maximum was 2.8 in 1874.

Cancer. — The deaths from cancer in 1892 were 1,402, as compared with 1,395 in 1891 and 1,387 in 1890.

The death rate from this cause per 10,000 of the living population was 5.9 in 1892 and the percentage of the total mortality was 2.87.

The minimum death rate from this cause for the twenty-year period was 3.5 per 10,000 in 1875, and the maximum was 6.2 in 1890.

There was a comparatively steady increase in the death rate from cancer from 1877 to 1890 and then a slight decrease in the last three years of the period.

Kidney Diseases. — The number of deaths from kidney diseases in 1892 was 1,535, as compared with 1,474 in 1891 and 1,273 in 1890.

The death rate per 10,000 of the estimated population from this group of causes in 1892 was 6.5 and the percentage of the total mortality was 3.15.

There was an increase with considerable regularity in the mortality from this cause during the twenty-year period, from a minimum of 2.9 per 10,000 of the population in 1873 to the maximum of 6.5 per 10,000 in 1892. This excessive increase is, however, more apparent than real, and may be interpreted as mainly due to more intelligent methods of diagnosis.

Heart Diseases. — The number of deaths from heart diseases registered in 1892 was 3,733, as compared with 3,592 in 1891 and 3,417 in 1890.

The death rate per 10,000 of the estimated population from this group of causes was 15.7 and the percentage of the total mortality was 7.65.

There has been a tolerably uniform increase in the death rate from this group of causes during the twenty-year period, the minimum death rate being 7.9 per 10,000 in 1873, '74 and '77 and the maximum 15.7 in 1892.

Brain Diseases. — This group includes the deaths attributed to apoplexy, paralysis, insanity, the indefinite term "cephalitis," softening of the brain and other unspecified diseases of the brain, the whole number of deaths from this group in 1892 being 5,036 as compared with 4,711 in 1891 and 4,389 in 1890.

The death rate per 10,000 of the estimated population from these causes in 1892 was 21.2 and the percentage of the total mortality was 10.33.

The minimum death rate from this cause for the twenty-year period was 13.5 in 1877, and the maximum was 21.4 in 1888. The mean death rate from these causes in the last half of the period was considerably greater than that of the first half. For the last eight years of the period the death rate from these causes was nearly stationary.

The deaths from local diseases in Massachusetts have not differed very greatly in their relative incidence upon the population, from those of England, as is shown in the following quotation from the Registrar General's Fifty-fourth Annual Report for 1891.

"*Local Diseases.* — The most noticeable feature presented by the diseases included in this class was the great increase of mortality from diseases of the Circulatory and Respiratory Systems. The rates respectively were 1,826 and 4,474 per million living, and in each case the highest on record. The explanation is doubtless to be found in the prevalence of epidemic influenza. The deaths from nervous diseases, however, showed no such increase. They were in the proportion of 1,748 to a million living; and this rate differed but little from those of the three next preceding years. The mortality from diseases of the Urinary System was 467 per million living, this being the highest rate yet recorded, and marking a further step in the almost continuous increase shown for a long series of years under this heading."

From certain infectious causes not mentioned in the foregoing enumeration there were the following numbers of deaths in 1892; those of 1891 are also presented, for the purpose of comparison: —

	Number of Deaths.			Number of Deaths.	
	1891.	1892.		1891.	1892.
Cerebro-spinal meningitis, .	154	86	Diarrhœa, ...	639	584
Erysipelas, ...	210	234	Malarial fevers, . . .	62	81
Puerperal fever, . . .	56	81	Hydrophobia, . . .	9	1
Influenza, ...	546	967	Glanders, ...	1	0
Dysentery, ...	234	198	Malignant pustule, . .	1	5

Malarial Fevers. — There were in all 81 deaths registered in 1892 from ague and remittent fevers. These occurred as follows: —

Worcester County, ...	16	Berkshire County, ...	3
Hampden "	15	Dukes "	1
Middlesex "	10	Franklin "	1
Suffolk "	9	Plymouth "	1
Bristol "	8	Barnstable "	0
Essex "	6	Nantucket "	0
Hampshire "	6		
Norfolk, "	5	Total, ...	81

The number of registered deaths from the same causes in 1891 was 62, and in 1890 60, and the total number for the ten years ending with 1892 was 584.

Influenza. — For the purpose of comparison the statistics relating to influenza which were published in the last report (p. xxxiv.) and also in the Forty-ninth Registration Report, 1890, are here reproduced together with those of 1892.

The deaths from certain diseases of the respiratory organs and from heart diseases are also given in the same table.

Mortality from All Causes, and from Influenza, Pneumonia, Phthisis, Bronchitis and Heart Diseases, by Months, for 1889, 1890, 1891 and 1892.

1889.

Causes.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Influenza, .	2	2	3	3	1	1	1	-	-	2	-	12	27
Pneumonia, .	394	358	463	436	328	165	117	114	119	232	291	423	3,440
Phthisis, . .	492	431	482	507	463	466	426	470	463	458	415	513	5,581
Bronchitis, .	109	135	173	147	92	62	62	70	84	111	109	122	1,276
Heart diseases,	278	233	273	279	289	235	266	245	210	271	237	299	3,115
Total, . .	1,275	1,159	1,394	1,372	1,173	929	872	899	876	1,069	1,052	1,369	13,439
All causes, .	3,237	3,064	3,516	3,573	3,353	3,121	4,224	4,213	3,650	3,868	2,984	3,474	41,777

1890.

Causes.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Influenza, .	246	65	32	21	9	8	5	1	4	5	6	9	411
Pneumonia, .	1,072	397	396	452	55	191	138	108	113	210	265	411	4,038
Phthisis, . .	733	477	530	512	488	451	446	437	436	418	424	439	5,791
Bronchitis, .	298	136	195	168	129	86	63	53	72	89	106	138	1,533
Heart diseases,	406	273	291	283	282	226	242	235	280	298	265	336	3,417
Total, . .	2,755	1,348	1,444	1,436	1,193	962	894	834	905	1,020	1,066	1,333	15,190
All causes, .	5,300	3,273	3,583	3,437	3,249	2,840	3,962	4,545	3,615	3,223	3,021	3,480	43,528

1891.

Causes.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Influenza, .	9	9	23	89	107	36	12	9	9	5	6	232	546
Pneumonia, .	474	377	473	577	549	233	136	93	92	177	318	838	4,337
Phthisis, . .	459	405	500	510	504	427	436	422	423	463	405	530	5,484
Bronchitis, .	154	158	166	157	170	121	86	58	73	113	133	269	1,658
Heart diseases,	366	272	315	307	319	244	250	279	255	307	300	378	3,592
Total, . .	1,462	1,221	1,477	1,640	1,649	1,061	920	861	852	1,065	1,162	2,247	15,617
All causes, .	3,578	3,133	3,714	3,802	3,795	3,126	4,070	4,455	3,765	3,714	3,318	4,715	45,185

1892.

Causes.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Influenza, .	573	180	71	48	26	17	12	4	5	9	16	11	967
Pneumonia, .	1,450	595	544	505	400	196	128	100	161	200	294	447	5,020
Phthisis, . .	587	447	539	515	546	424	455	455	404	462	441	464	5,739
Bronchitis, .	478	246	226	145	135	82	50	56	74	126	144	124	1,886
Heart diseases,	483	327	373	343	310	267	237	285	258	254	314	282	3,733
Total, . .	3,571	1,795	1,753	1,551	1,417	986	882	900	902	1,051	1,209	1,328	17,345
All causes, .	6,309	3,896	4,161	3,990	3,786	3,197	4,565	4,717	3,664	3,484	3,357	3,636	48,762

An examination of these tables shows quite plainly the sharp rise in the mortality from influenza with a coincident rise in the mortality from pneumonia, phthisis, bronchitis and heart diseases in the winter of 1889–90, culminating in January; another epidemic of less magnitude in the spring of 1891, culminating in April and May, and the still greater epidemic of the winter of 1891 and '92 culminating in January, 1892.

These, together with other minor causes, increased the mortality of January 1892 to 6,309 deaths which was greater by 2,246 than the mean monthly mortality of the year, and greater by more than 1,000 than the mortality of any month in the ten-year period (1883–1892).

Hydrophobia. — The mortality from this cause which had attained to considerable numbers in 1889 and 1890, again fell to a single death in 1892.

During the six years ending with 1887 there had been no reported deaths from this cause. There were then 2 deaths from hydrophobia in 1888, 14 in 1889, 17 in 1890, 9 in 1891 and 1 in 1892.

The whole number of deaths from this cause for the period of registration ending with 1892 (fifty-one years and eight months) was 116, of which number 96 or 82.8 per cent. were males and 20 were females.

Mortality of Cities.

The rapid growth of the urban population in Massachusetts as contrasted with that of the smaller towns is a sufficient reason for publishing in a separate table the number of deaths from all causes together with those from the principal infectious diseases in each city in the State.

By this table it appears that the total number of deaths in the cities in 1892 was 32,202 as compared with 30,049 in 1891, and those in the towns were 16,560 as compared with 15,136 in 1891.

The population of the 30 cities including Medford and Everett, by the census of 1890 was 1,394,444 or 62.3 per cent. and that of the towns was 844,499 or 37.7 per cent. of the total population, while a half century earlier, the census showed that the cities (or places having more than 10,000 in each) constituted less than one-fourth of the population.

Deaths 1891 and 1892, Mean Death-rate of Five Census Years, and Deaths from Certain Infectious Diseases, 1892, in the Urban Population of Massachusetts.

Number.		Total Deaths, 1891.	Total Deaths, 1892.	Mean Death Rate, Five Census Years (1870-90).	Small-pox.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Typhoid Fever.	Cholera Infantum.	Consumption.	Pneumonia.	Whooping-cough.
1	Boston,	10,536	11,221	24.1	-	34	261	485	137	568	1,552	1,144	67
2	Worcester,	1,601	1,817	19.7	-	1	15	69	17	127	207	158	11
3	Lowell,	1,975	2,229	22.5	-	11	13	28	77	229	231	215	7
4	Fall River,	1,914	1,968	23.4	-	8	27	59	27	228	163	175	27
5	Cambridge,	1,449	1,523	19.9	-	2	16	53	15	92	216	132	9
6	Lynn,	969	1,066	17.8	-	1	3	30	13	74	134	136	5
7	Lawrence,	1,129	1,246	22.5	-	1	44	28	50	130	95	156	7
8	Springfield,	886	995	19.3	-	8	14	48	39	63	116	76	7
9	New Bedford,	984	991	20.9	2	-	4	10	15	72	125	84	8
10	Somerville,	782	718	18.2	-	-	13	8	14	38	90	68	4
11	Holyoke,	713	922	23.1	-	8	13	71	16	72	88	102	11
12	Salem,	606	717	22.1	-	-	3	11	18	46	77	78	-
13	Chelsea,	678	650	19.7	-	-	13	18	10	34	83	71	3
14	Haverhill,	556	495	17.8	-	-	5	2	13	26	80	44	2
15	Brockton,	410	416	16.2	-	1	2	15	8	16	49	52	1
16	Taunton,	445	595	19.5	-	-	8	12	9	30	61	67	-
17	Gloucester,	419	431	21.8	-	-	4	2	3	16	50	48	7
18	Newton,	349	393	13.1	-	1	-	8	4	17	46	46	-
19	Malden,	399	452	17.0	-	-	7	13	6	23	52	29	2
20	Fitchburg,	409	445	17.0	-	-	2	6	-	40	48	54	3
21	Waltham,	299	319	15.8	-	-	10	-	5	7	59	46	-
22	Pittsfield,	315	322	18.3	-	-	10	12	6	9	37	51	1
23	Quincy,	292	288	18.7	-	1	2	10	7	11	51	17	-
24	Northampton,	268	267	17.2	-	-	6	9	3	20	27	28	1
25	Chicopee,	321	395	20.5	-	1	7	5	24	36	41	39	4
26	Newburyport,	304	310	21.1	-	-	4	23	3	14	42	23	2
27	Marlborough,	202	241	17.2	-	-	3	3	8	17	30	30	7
28	Woburn,	263	270	18.3	-	-	4	8	8	12	35	25	1
29	Medford,	149	207	-	-	-	3	3	2	15	18	14	-
30	Everett,	227	255	-	-	-	3	10	1	19	30	28	4
	The 30 cities,	30,049	32,202	21.4	2	73	519	1,059	553	2,096	3,928	3,236	201
	The rest of the State,	15,136	16,560	17.5	0	15	150	396	274	802	1,811	1,784	47
	The whole State,	45,185	48,762	19.7	2	88	669	1,455	827	1,294	5,739	5,020	248

The growth of the cities included in the foregoing table was approximately at the rate of $3\frac{7}{10}$ per cent. per year for the period 1885 to 1890. While that of the remainder of the State was at the rate of only $1\frac{68}{100}$ per cent. (geometric rate).

Estimating the growth in 1892 at the same rates for these two classes of the population, the mortality rates from the principal diseases included in the foregoing table are presented in the following table. In the two lower lines the mortality rates are reduced to a standard of 1,000 in the urban population for the convenience of comparison, and may be read as follows: —

For every 1,000 deaths from all causes in the urban population, there were 879 deaths in the remainder of the State in equal numbers living. For every 1,000 deaths from consumption in the urban population, there were 794 deaths in the remainder of the State in equal numbers living.

Death Rates from Certain Diseases in 1892, per 10,000 of the Estimated Living Population, and the same Reduced to a Standard of 1,000 in the Urban or Dense Population.

	All Causes, Per 1,000.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Typhoid Fever.	Cholera Infantum.	Phthisis.	Pneumonia.	Whooping-cough.
		Per 10,000 of Population.							
Urban population, . . .	21.5	.49	3.46	7.1	3.7	13.9	26.2	21.6	1.34
Remainder of the State, . .	18.9	.17	1.7	4.5	3.1	9.2	20.8	20.4	.54
Urban population, . . .	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Remainder of the State, . .	879	347	491	634	838	662	794	944	403

The Significance of General or Crude Death Rates.

The crude death rate obtained by estimating the ratio of the number of deaths to the living population has been employed for many years as an index of the sanitary condition of a community, and for comparing its sanitary condition with that of other communities. While this method may be trusted in the comparison of the death rates of a nation, a State, county, city or town at different periods of time (since the age and sex distribution of communities remain fairly constant when comparisons are made for brief periods or successive years), it cannot be trusted for the comparison of

different towns, cities, States and countries with each other, when the age and sex distribution differs widely as for example, in our own State, in the case of Barnstable and Bristol counties, or Barnstable and Suffolk.

In support of this statement Dr. Farr says "Independently of other causes of variation, the mortality of different populations will differ according as they consist of numbers in various proportions at the ages at which the mortality is high or low."

"It is not too much to say that death rates calculated on the gross population are practically worthless as evidence of the sanitary conditions of communities less than entire nations." Dr. E. F. Willoughby, Hand-book of Public Health and Demography.

For the purpose of facilitating the methods of correcting death rates according to age and sex distribution, Dr. Ogle of the British Registrar General's office and J. Körösi, Director of Statistics of Hungary, have proposed the employment of standards of population in which a normal or standard distribution of ages and sexes is presented. For this purpose Dr. Ogle combines the populations of seven principal European countries including about 170 million inhabitants and presents a table in which the average distribution of these populations is given by sexes and age periods, the whole number of such periods being twelve. For the purpose of comparison with other countries, States, cities or smaller communities, this method has the disadvantage of requiring an amount of computation which becomes burdensome, and secondly, the age periods employed above 20 years do not correspond with those which have usually been adopted in Massachusetts and other American communities, and while there are some advantages in adopting a distribution into the periods 25–35, 35–45, etc., instead of 20–30, 30–40, etc., the differences are so slight as not to make it advisable to change the existing methods.

Körösi of Buda-Pesth suggests a method which is less cumbrous than the foregoing. He does not deem it essential for this purpose to adopt a sex distribution, but employs a distribution of ages only and divides them into four periods as follows: —

All ages under one year.
One to twenty years.
Twenty to fifty years.
All over fifty years.

For the purpose of comparison he suggests the use of a standard representing a healthy population having a constantly low death rate as is the case with Sweden.

The foregoing age periods were adopted by M. Körösi after trials with different periods. They differ somewhat from those which have been in use, but he states that it "was found to be preferable to group the first year separately, and that there was no sensible change produced by placing the next nineteen years in one single group."

The Returns of Medical Examiners.

The whole number of returns of medical examiners for the year 1892, under the provisions of the inquest laws, was 2,210.

Of this number, 72 or 3.26 per cent. were deaths by homicide, 274 or 12.40 per cent. were suicides, 974 or 44.07 per cent. were deaths from accident or negligence, and 890 or 40.27 per cent. were the result of causes not due to violence, but to different natural causes and alcoholism. More than one-half of this group were from heart diseases and diseases of the nervous system usually of a sudden character.

Sex. — Out of the whole number of deaths returned by the medical examiners 1,642 or 74.3 were those of males, 560 or 25.3 were of females, and the sex of 8 was not stated.

The following summary presents the data of these cases by sexes for the period of eight years (1885–92).

Years.	Sex.						
	Males.	Percentages.	Females.	Percentages.	Unspecified.	Percentages.	Totals.
1885,	973	76.1	286	22.4	19	1.5	1,278
1886,	1,027	74.5	319	23.2	32	2.3	1,378
1887,	1,191	76.5	350	22.5	15	1.0	1,556
1888,	1,261	76.4	373	22.6	17	1.0	1,651
1889,	1,253	75.8	388	23.4	13	0.8	1,654
1890,	1,303	73.5	449	25.3	21	1.2	1,773
1891,	1,362	74.0	457	24.8	21	1.2	1,840
1892,	1,642	74.3	560	25.3	8	0.4	2,210
Totals,	10,012	-	3,182	-	146	-	13,340
Means,	-	75.0	-	23.8	-	1.2	-

In the following summary these deaths are classified into four groups as in previous reports. The percentage of each group for each year being stated : —

Years.	Homicide.		Suicide.		Accident or Negligence.		Natural and Unknown Causes, Including Alcoholism.		Totals.
	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.	Number.	Per Cent.	
1885, ...	45	3.52	181	14.17	567	44.37	485	37.94	1,278
1886, ...	47	3.41	157	11.38	678	49.17	496	36.00	1,378
1887, ...	52	3.34	173	11.12	748	48.07	583	37.47	1,556
1888, ...	52	3.15	190	11.51	785	47.55	624	37.79	1,651
1889, ...	51	3.08	199	12.03	792	47.89	612	37.00	1,654
1890, ...	35	1.97	196	11.05	862	48.62	680	38.36	1,773
1891, ...	60	3.26	187	10.16	866	47.06	727	39.52	1,840
1892, ...	72	3.26	274	12.40	974	44.07	890	40.27	2,210
Totals, . .	414	-	1,557	-	6,272	-	5,097	-	13,340
Means, . .	-	3.10	-	11.67	-	47.01	-	38.22	-

The ratio of deaths investigated by the medical examiners to the estimated population of Massachusetts in 1892 was .99 of 1 per 1,000 and the percentage of the total mortality was 4.5.

In England during the year 1891 the ratio of deaths submitted to inquest, as compared with the total population was 1.12 per 1,000 and the percentage of the total mortality was 5.5.

Of the total number of deaths (32,432) referred to the coroners for inquest 12,946 or 39.9 per cent. were not due to violence ; this percentage being very nearly identical with the mean for Massachusetts for the eight years (1885–92) ; 51.46 per cent. of the whole were deaths from accident and negligence ; 7.66 per cent. were deaths from suicide, and .97 of 1 per cent. were deaths determined to be due to murder and manslaughter.

Of the deaths due to accident, 77.2 per cent., and of those due to suicide, 75 per cent. were of males, while the deaths from murder and manslaughter were divided between the sexes in nearly equal numbers, 158 males and 157 females.

WATER SUPPLY AND SEWERAGE.

The general law giving to the State Board of Health supervision of inland waters, and imposing certain duties upon the Board in relation to water supplies and systems of sewerage and sewage disposal has been so frequently quoted in the recent reports of the Board that it is not essential to quote the statute again in full.

Acting under the Statutes of 1888 the work of the Board in this direction has been conducted during the past year in the same manner as in previous years. This work now constitutes a very important branch of the operations of the Board.

The report of this department of the Board for 1893 comprises the following topics: —

The advice of the Board to the authorities of cities, towns and corporations and individuals upon proposed or existing systems of water supply and sewage disposal under the provisions of section 3 of chapter 375 of the Acts of 1888.

A continuation of the examination of water supplies, comprising the results of chemical and microscopical examinations of public water supplies. The examination of the waters of the following rivers, the Blackstone, Charles, Merrimack, Nashua, Neponset, Housatonic and Taunton were continued and other examinations were made of the Charles, Deerfield, Shawsheen and Ware and the Nashua and its tributaries in connection with the investigations for a Metropolitan water supply.

In the summary of water supply statistics it appears that 146 cities and towns, having a total population of 1,949,455, were provided with water supplies, the majority of these places having in each a population of over 4,000. There were also 206 towns which were not provided with public water supplies only one of which had a population of more than 4,500.

The total population of places not supplied was 289,488 or but little more the one-eighth of the population of the State.

The paper by Professor Drown upon "the Amount of and Character of Organic Matter in Soils and its Bearing on the Storage of Water in Reservoirs," has a practical bearing upon all water supplies where artificial storage basins are constructed by impounding water in valleys and meadows having a surface either partially or wholly of loam or peat.

Mr. Geo. W. Fuller, biologist in charge of the Lawrence Experiment Station, details the work performed at the station during the sixth year of its existence. The principal topics treated of in his report are the character of the sewage used for experiment, the average purification attained, the permanency of filters, their management, experiments upon rapid filtration of sewage from which the sludge has been removed, sub-surface application of sewage, experiments with sand clogged by sewage, effect of polarite in removing color of dye-stuffs in sewage, removal of bacteria, work of the sewage filters in 1893, filtration of water, effects of rate of filtration, depth of material, size of sand grains, scraping, disturbing upper layer of filter, removal of layer of loam, freezing surface layers, rapidly filling from below, amount of loss of head and method of application of water upon its bacterial purification. A detailed account is given of the work of the water filters during 1893 together with the chemical and bacterial analyses of the water supplied and of the effluent water of the Lawrence city filter for the first seven months of its operation.

Hiram F. Mills, C.E., member of the Board, presents a description of the "Filter of the Water Supply of the City of Lawrence and its Results," and shows in this paper, —

1. "The insufficiency of the self-purification of streams.

2. The ready conveyance of typhoid fever down a stream by sewage-polluted drinking water.

3. The practicability of protecting a community against an infected drinking water supply by natural sand filtration."

The paper entitled "Sewage Purification of Cities and Towns in Massachusetts" presents a brief description together with chemical analyses of sewage and effluents from the systems in use in the following places: Amherst, Norfolk county jail, Framingham, Gardner, Lenox, Marlborough, Medfield, Wellesley College and Westborough.

Mr. Allen Hazen, the chemist in charge at the Experiment Station at Lawrence in 1890–93, was appointed as chemist of the department of water supply, sewerage and fire protection at the World's Columbian Exposition at Chicago, and presents in this volume a description of the process there employed for disposal of the sewage of the Exposition by precipitation and the results attained by this process.

Metropolitan Water Supply.

Within the period of the past forty years or more and since the beginning of the general introduction of a public water supply into Boston the growth of the city has been rapid, and this growth has extended outward, until the suburban municipalities have acquired a population nearly as large as that of the city, the whole district within ten miles of and including Boston containing nearly a million inhabitants.

Public water supplies have now been introduced into each of the twenty-eight cities and towns embraced within this limit. The rapid growth of the towns has not only been attended with an increase in the absolute consumption of water in the district, but the relative or *per capita* consumption has also been considerably increased. To supply this demand very much of the available territory suitable for use as sources for yielding water has been taken by the cities and towns within this district. In some instances the density of the population living upon the area of the different water-sheds has increased to such an extent as to become a serious menace to the health of the population consuming the water, in consequence of the increased pollution which usually follows a corresponding increase of population.

In the words of the present report (p. 6) "The experience of the past year (1893) has emphasized the urgent need of a new water supply for this district, as not only has the water supply of Boston and the district supplied from Mystic Lake been nearly exhausted, as above indicated, but the water supplies of a majority of the places in the Metropolitan district have been in a similar condition."

The urgent demands of the authorities of these municipalities for larger and purer supplies of water finally resulted in legislative action, and the following law was enacted by the Legislature of 1893, entrusting to the State Board of Health the duty of making a general investigation of the subject of a water supply for this Metropolitan district.

[Acts of 1893, Chapter 459.]

An Act relative to procuring a water supply for the city of Boston and its suburbs.

Be it enacted, etc., as follows:

Section 1. The state board of health is hereby authorized and directed to investigate, consider and report upon the question of a water supply for

the city of Boston and its suburbs within a radius of ten miles from the state house, and for such other cities and towns as in its opinion should be included in connection therewith.

SECT. 2. The said board shall forthwith proceed to investigate and consider this subject, including all questions relating to the quantity of water to be obtained from available sources, its quality, the best methods of protecting the purity of the water, the construction, operation and maintenance of works for storing, conveying or purifying the water, the cost of the same, the damages to property, and all other matters pertaining to the subject.

SECT. 3. The said board shall have power to employ such engineering and other assistance and to incur such expenses as may be necessary for carrying out the provisions of this act.

SECT. 4. The said board shall report fully with plans and estimates to the legislature on or before the first Wednesday in January in the year eighteen hundred and ninety-five, and shall append to its report drafts of bills intended to accomplish the recommendations of the board.

SECT. 5. The total amount of money which shall be expended out of the treasury of the Commonwealth in carrying out the provisions of this act shall not exceed forty thousand dollars. The Commonwealth shall be reimbursed for the amount expended by the cities and towns which are to receive the benefit of the system recommended in the report, in proportion to the population of each.

SECT. 6. Before incurring any expense the board shall from time to time estimate the amounts required and shall submit the same to the governor and council for their approval, and no expense shall be incurred beyond the amount so estimated and approved.

SECT. 7. This act shall take effect upon its passage. [*Approved June 9, 1893.*

Immediately after the passage of this Act, the Board entered upon the work of investigation, and began the necessary surveys to ascertain the best supply for the district. This work has been carried on without interruption since June, 1893.

While it is too early to publish conclusions relative to a definite source of water supply for the district, it may be said that the investigations made up to the present time indicate that an abundant supply of good water for the Metropolitan District may be obtained without excessive expenditure.

Improvement of the Charles River.

By the provisions of Chapter 475 of the Acts of 1893, the Board of Metropolitan Park Commissioners and the State Board of Health were constituted a joint board to investigate "the sanitary condition and prepare plans for the improvement of the beds, shores and waters of the Charles River, between Charles River bridge and the Waltham line on Charles River, and for the removal of any nuisances therefrom."

The joint board, thus constituted, was authorized to employ engineers and experts and to incur necessary expenses not exceeding $5,000.

This act recognizes the existence of conditions in the specified portion of the river which have for a long time constituted a general nuisance, offensive to the sight and smell, in consequence of the serious pollution of the river and of the daily exposure of large areas of mud flats upon which the polluting matter in the river is deposited.

To remedy this foul and unsightly condition the Board has given its attention, and after surveying the territory and areas included in the provisions of the act and investigating the sanitary condition of the contiguous population, made its report to the Legislature in May, 1894 (House Doc. 775, 1894), the time for the presentation of the report having been extended by Chapter 57 of the Resolves of 1894.

The plan proposed involves the construction of a dam and a lock at the lower portion of the estuary above Craigie's bridge, by means of which the water above the dam will be kept at a constant level. While this dam may be regarded as the principal feature of the plan, other features are worthy of note, especially the treatment of the shores of the proposed basin.

One great improvement in this region is already nearly completed, the Metropolitan Sewerage System, which, when in operation, will remove a great amount of pollution from the river.

The report of the Landscape Architects to the joint board closes as follows: — "Charles River, freed from sewage, from defiling industries, from mud flats and from mud banks, and dedicated with its borders to the use and enjoyment of the public as a drainage channel, an open space, a parkway, a chain of playgrounds and a boating course, will perform its highest possible service to the Metropolitan com-

munity, and will return to the community profits, both tangible and intangible, which will annually increase."

Infectious Disease Hospitals.

The subject of providing separate accommodations for hospitals for persons suffering with infectious diseases of a dangerous character has become quite prominent during the past two or three years in Massachusetts cities, and is likely to become still more a subject of paramount importance in future years.

The fact that 400 such establishments exist in England alone, and the number there is constantly increasing, is sufficient to show the estimate in which they are held in Great Britain.

In response to a demand for information upon this subject, a paper has been prepared by the Secretary for the present report, containing the most recent information upon the subject, together with a brief compilation embodying the practice of other countries in this direction.

Summary of Weekly Mortality Reports.

Under this title may be found a summary of the returns sent to the office of the State Board at the close of each week from the principal cities and towns, of the deaths which have been reported to the local Boards of Health. These returns embrace a statement of the total number of deaths, the number of deaths of children under 5 years of age, and the number from each one of the principal infectious diseases.

This system of voluntary returns keeps the State Board informed of the progress of epidemics, their outbreak and their decline, and serves as a valuable index of the health of the population, its chief advantage consisting in its frequency and the fact that the Board receives its information direct from the local authorities.

Health of Towns.

In the portion of the report devoted to the health of towns may be found a digest of the principal facts of importance gathered from the city and town reports of Boards of Health of the year 1893.

This summary also contains a table in which are stated the number of cases of the principal infectious diseases which are reported to the local Boards of Health. In addition to the cases reported another parallel column contains the registered deaths from the same causes in these cities and towns and the ratio of fatality in the State at large.

Routine Work of the Board.

The Board, in the performance of its duties under the provisions of the Statutes, has held at least one meeting in each month during the year, with such meetings of its standing committees as were essential to the proper performance of its work. The work of the year is presented in detail under the different topics referring to the prescribed duties of the Board.

Advice has been given almost daily at the office to local Boards of Health and to individuals seeking advice upon sanitary questions, and in instances, where occasion required, visits have been made by the secretary and by the engineers of the Board to cities and towns for the purpose of making investigation and inspecting and giving advice.

One public hearing only was held during the year (on April 10, 1893) and that had reference to the taking of land for the sewage disposal of Brockton under the provisions of chapter 124 of the Acts of 1890.

The statistics of mortality have been compiled and published each week at the office of the Board in the form of a weekly bulletin, which also contains once a month a report of the work done in the line of food and drug inspection, together with the prosecutions made under the Food and Drug Acts. In addition to the foregoing, during the past year the statistics of reports of cases of infectious diseases returned under the provisions of chapter 302 of the Acts of 1893, have been introduced in these bulletins.

The following table presents certain statistical data relative to the routine work of the Board: —

Statistical Table for the Year ending Sept. 30, 1893.

Whole number of samples of foods and drugs examined during the year,		6,409
Samples of milk examined (included in the foregoing),		3,073
Whole number examined since beginning of work in 1883,		53,573
Whole number of samples of milk examined since beginning of work in 1883,		27,076
Number of warning notices issued relative to adulteration during the year,		423
Number of prosecutions against offenders during the year,		96
Number of convictions during the year,		92
Amount of fines secured during the year,		$2,476.00
Force employed at Boston, for food and drug inspection, chemists and assistants,	2	
At Amherst,	1	
		3
Inspectors,		3
Total,		6

Under the Provisions of the Act to protect the Purity of Inland Waters.

[This table applies to the calendar year ending Dec. 31, 1893.]

Statistical Table for the Year 1893.

Applications for advice from cities, towns and others: —		
Relating to water supply,		39
Relating to sewerage and drainage,		12
Total,		51
Number of samples of water examined chemically and microscopically at the Massachusetts Institute of Technology,		1,731
Number of samples of soil examined chemically at the Massachusetts Institute of Technology,		52
Number of samples of sewage and water examined chemically and bacterially at the Lawrence Experiment Station,		2,176
Number of samples of sand examined chemically and bacterially at the Lawrence Experiment Station,		513
Number of samples of sand examined mechanically at the Lawrence Experiment Station,		314
Additional samples examined bacterially at the Lawrence Experiment Station,		11,850
Total number of samples examined,		16,636
Force employed at 13 Beacon Street: —*		
Chief engineer,	1	
Assistant engineers,	2	
Stenographer and clerk,	1	
		4
At Massachusetts Institute of Technology: —		
Chief chemist,†	1	
Assistant chemist,	5	
Chief biologist,†	1	
Assistant biologists,	1	
		8
At Lawrence Experiment Station: —		
Chemists,	2	
Bacteriologists,	3	
Other assistants and laborers,	4	
		9
Total ordinary force,		21

* Not including the force employed upon the Metropolitan Water Supply investigations.

† The chief chemist and biologist, although located at the Massachusetts Institute of Technology, have the oversight of the chemical and biological work at the Lawrence Experiment Station.

The number of applications received since July, 1886, when the act relating to water supply and sewerage first went into operation, is as follows: —

1886,	8
1887,	22
1888,	28
1889,	38
1890,	23
1891,	53
1892,	56
1893,	51
Total,	279

Recommendations.

The following recommendations were made to the Legislature at the beginning of the session of 1894: —

1. With reference to the continuance of the work of the Board under the provisions of chapter 375 of the Acts of 1888 the Board recommends the continuance of the investigations already commenced and those indicated as desirable in the report upon Water Supply and Sewerage (Senate Doc. 4, 1894).

For these purposes, and to make the necessary investigations in order to advise cities, towns, corporations and individuals in regard to the best method of assuring the purity of intended or existing water supplies, and the best method of disposing of sewage, and to carry out the other provisions of chapter 375 of the Acts of 1888, the Board estimates that the sum of $27,000 will be required.

2. As to Notification of Contagious Diseases.

That the laws in reference to the notification of contagious diseases to certain State authorities be so amended that the law now in force in regard to small-pox shall be extended to include other diseases dangerous to the public health.

3. State Vaccine Institution.

In its Twentieth Annual Report, 1888, the State Board of Health introduced the subject of establishing in the State one or more places at which vaccine lymph could be furnished under the supervision of the State, so that regular supplies of lymph could be furnished to all State institutions, to the local authorities of cities and towns, and to such physicians as might choose to obtain their lymph from such an institution.

This plan is adopted at present in nearly all foreign countries where vaccination is practised, and with the most successful result. The plan of public vaccinal institutes has reached its highest development in Germany, where at least thirty such establishments, well equipped and under thorough administration, furnish lymph for vaccination to all who desire it. By this plan the purity of the lymph can be satisfactorily assured, and the physician or local board of health can procure it direct from the institution, thus avoiding the delay of ordering through agents and middlemen.

As a result of this plan as well as of their very thorough enforcement of the laws, Germany is to-day more free from the scourge of small-pox than any other country in the world.

The Board therefore recommends that an appropriation of ________ be made for the purpose of carrying out this plan, under the supervision of such authority as the Legislature may direct.

4. *As to Vital Statistics.*

That, inasmuch as an intimate study and knowledge of the vital statistics of a community are the basis of wise sanitary administration, the data gathered annually by the Secretary of the Commonwealth, in accordance with the provisions of existing statutes, be submitted in their entirety to the Board of Health for such consideration and report as may seem to promote most fully the public welfare. Such a course would place this State in harmony with the usage in nearly all the states of this Union having registration, and in the civilized countries of Europe.

5. *As to Medical Inspectors of Health.*

The following bill was recommended: —

PROVIDING FOR THE APPOINTMENT OF ADVISORY MEDICAL INSPECTORS OF HEALTH THROUGHOUT THE COMMONWEALTH.

Be it enacted, etc., as follows:

SECTION 1. The governor, by and with the advice and consent of the council, shall, as soon as may be after the passage of this act, divide the Commonwealth into such number of districts, to be known as health districts, as he may deem proper and necessary for carrying out the purposes of this act.

SECT. 2. After the division provided in the foregoing section the governor shall nominate, and by and with the advice and consent of the council, shall appoint in each health district one able and discreet person, learned in the science of medicine, to be advisory medical inspector of health in said district. Every such nomination shall be made at least seven days prior to the appointment.

SECT. 3. Said advisory medical inspectors of health shall hold their offices for a period of seven years from the time of their respective appoint-

ments, and shall be liable to removal from office by the governor and council at any time for cause shown.

SECT. 4. Each advisory medical inspector of health shall reside in the district to which he is appointed, and his removal therefrom shall be equivalent to a resignation of his office. His powers and duties shall be advisory only. He shall inform himself respecting all influences affecting or threatening to affect injuriously the public health within the district, and shall promptly notify the local authorities of the existence of all conditions affecting or likely to affect the health of the district, and shall advise with said authorities as to the best methods of controlling the same.

SECT. 5. Each advisory medical inspector of health shall keep a record of his proceedings and observations, and shall annually make a report to the health authorities of each city or town within his district touching matters affecting said city or town, and shall transmit a copy of each report to the State Board of Health on or before the thirty-first day of October in each year.

SECT. 6. Each advisory medical inspector of health shall from time to time as requested furnish to the State Board of Health information touching the sanitary condition of the whole or any part of his district. He may make such reports and suggestions to the State Board of Health or to the local authorities as he may deem advisable; but shall in every instance forward to the State board a copy of any such communication with the local authorities.

SECT. 7. The governor, by and with the advice of the council, shall establish from time to time the salaries of said advisory medical inspectors of health, having reference in each district to the extent of territory, the number of inhabitants, the character of the business there carried on, and the amount of time likely to be required for the proper discharge of the duties. The salary thus established shall be paid from the treasury of the Commonwealth quarterly.

SECT. 8. This act shall take effect upon its passage.

EXPENDITURES.

The work of the Board is conducted under the provisions of several statutes, and for its different departments of work three appropriations are annually made, one for its general work, one for the inspection of food and drugs and a third for carrying out the provisions of chapter 375 of the Acts of 1888, relating to the protection of the purity of inland waters.

The appropriations for these different departments of work during 1893 were as follows: —

For the general work of the Board,	$10,800 00
For food and drug inspection,	11,500 00
For work under the provisions of chapter 375, Acts of 1888,	27,000 00
	$49,300 00

In addition to these regular lines of work the Board was charged with the duty of investigating the question of a general water supply for the city of Boston and the suburban cities and towns to the distance of ten miles from the city.

For this investigation the Board was authorized to expend a sum not exceeding $40,000, of which sum there was appropriated in 1893 the sum of $15,000.

The expenditures under the foregoing appropriations were as follows: —

FOR THE GENERAL WORK OF THE BOARD.

Salaries,	$4,819 96
Printing,	1,325 15
Travelling,	1,140 70
Special investigations,	488 78
Postage,	207 61
Books, subscriptions and binding,	306 68
Express,	220 23
Stationery,	152 42
Telephone,	127 05
Type-writer and library supplies,	19 30
Office incidentals,	54 72
Messenger services,	257 27
Telegrams,	7 33
Draughting wood-cuts,	31 50
	$9,158 70

FOR FOOD AND DRUG INSPECTION. FOR YEAR ENDING SEPT. 30, 1893.

Salaries of analysts,	$4,400 00
Salaries of inspectors,	3,900 00
Travelling expenses and purchase of samples,	1,661 75
Apparatus and chemicals,	235 63
Rent at Harvard Medical School,	125 00
Chemical analysis (by other chemists),	2 00
Furniture and fittings at laboratory,	26 52
Legal services,	45 00
Printing,	4 85
Gas,	33 36
Extra services,	20 00
Total,	$10,454 11

Expenses under Chapter 375 of Acts of 1888. Protection of Purity of Inland Waters. For Calendar Year 1893.

Salaries, including wages of laborers at Lawrence Experiment Station,	$22,743 40
Apparatus and materials,	1,896 73
Rent of rooms at Massachusetts Institution of Technology,	900 00
Rent of Lawrence Experiment Station,	125 00
Travelling expenses,	195 81
Express charges,	420 95
Use of tools and office, Lawrence Experiment Station,	412 32
Printing,	74 54
Stationery and drawing materials,	86 21
Maps, blue prints and photographs,	54 06
Furniture,	43 00
Paid for collecting samples of water,	8 25
Postage stamps,	27 90
Messengers and telegrams,	7 82
Total,	$26,995 99

For Expenses in Investigation of Water Supply of Boston and Suburban Towns.

[Acts of 1893, Chapter 459.]

Salaries,	$7,455 83
Services and expenses, experts,	162 25
Apparatus and repairs, borings, drawing and surveying instruments, etc.,	1,249 00
Travelling expenses and board of employés,	1,200 68
Maps, etc.,	43 50
Stationery and account books,	71 20
Hardware, hose, pump, pipe, etc.,	596 87
Lumber,	45 34
Freight, express, etc.,	15 99
Office rent and incidentals,	72 27
	$10,912 93

A statement of the expenditures relating to the exhibit of the Board at the World's Columbian Exposition may be found on page xxiii.

H. P. WALCOTT,
J. W. HASTINGS,
H. F. MILLS,
F. W. DRAPER,
G. C. TOBEY,
J. W. HULL,
C. H. PORTER,
State Board of Health.

WATER SUPPLY

AND

SEWERAGE.

ADVICE TO CITIES AND TOWNS.

WATER SUPPLY AND SEWERAGE.*

[Report required by the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage."]

The following report contains the substance of the replies made by the Board to those cities, towns, corporations and individuals which have applied to the Board for its advice relative to systems of water supply, drainage and sewerage, under the provisions of chapter 375 of the Acts of 1888. It also includes a summary of the work done by the Board in connection with the examination of water supplies and rivers, and the purification of sewage.

As one result of the studies of the Board, in connection with the investigations made at the Experiment Station, there has been constructed during the past year by the city of Lawrence a filter-bed covering an area of two and a half acres which now filters the domestic water supply for about 47,000 people. This water supply is derived from the Merrimack River, which receives the drainage of a large part of New Hampshire, and the sewage of Lowell enters only nine miles above the intake of the Lawrence water works. There has been in past years a great increase in the number of deaths by typhoid fever in Lowell and in Lawrence in the late fall and winter months, after the disease had spent its force and nearly ceased in the towns and cities up the river.

The studies of the Board led them to conclude that this large number of deaths, often, in Lawrence, exceeding the number in the city of Boston in the same months, was due to disease germs brought down the river and distributed to the citizens in their drinking water; and after making filters at the Experiment Station that removed all the disease germs

* The first pages of this report were contained in a report made to the Legislature Jan. 10, 1894 (Senate Document, No. 4). A portion of the report then made, relating to the work done at the Lawrence Experiment Station, is not reproduced, because a more complete account of the work done at this place will be found in a subsequent part of this volume.

put into the water applied to them, the Board advised the city of Lawrence to construct a filter under the direction of the Board, and to purify their drinking water. The filter was commenced in the fall of 1892, and finished, at a cost of about $65,000, in September, 1893. Since September 20 all the water that has been pumped to the city reservoir has first passed through the filter.

Very frequent examinations of the water show that 98 per cent. of all of the bacteria in the river water applied to the filter are removed directly by it, and in addition to this it removes a large part of the organic matter from the water and converts much of it to mineral matter, thus depriving the remaining bacteria of food material and rendering the conditions of life so unfavorable that the bacteria decrease as the water goes on through the reservoir and through the distributing pipes, until when the water reaches the citizens there remains but one-half of 1 per cent. of the number of bacteria in the river water; that is, 99½ per cent. of all have been removed.

The experiments of the Board indicate that the small numbers remaining are of a few hardy kinds that are not known to be in any way injurious to health; and leave the strong probability that all the disease-producing germs have been removed.

The result upon the health of the people of Lawrence is very marked and very satisfactory. The number of deaths from typhoid fever in Lawrence for the three months of October, November and December during the past five years has averaged eighteen; the number of deaths this year, since the water has been filtered, in the same three months, has been four.

At the end of the year 1893 all of the 30 cities in the Commonwealth, and 116 towns out of a total of 322, were provided with a public water supply. The total population of the communities having a public water supply is 87.1 per cent. of the total population of the State.

There are now but 6 towns which, by the census of 1890, had a population exceeding 4,000, which are not provided with a public water supply. The names of these towns, with their respective populations in 1890, are as follows: Black-

stone, 6,138; Ipswich, 4,439; Millbury, 4,428; Winchendon, 4,390; Rockport, 4,087; and Barnstable, 4,023.

Twenty-eight cities and 67 towns, having together a total population of 1,704,510, own their water works, while 2 cities and 49 towns, with a total population of 244,945, are supplied by private companies.

The flow of the streams in the year 1893, taken as a whole, as indicated by the volume of water flowing in Sudbury River, has been a very little below the average for a long series of years; but the seasonal distribution of the flow has been very uneven, the year resembling in this respect 1891. During the four months from February to May, inclusive, the flow was 23 per cent. above the average, and greater than in all but three of the previous eighteen years. On the other hand, the flow for the six months from June to November, inclusive, was 46 per cent. below the average for these months, and there were only four years of the previous eighteen when the flow during the same months was lower.

A year of this unusual character affects very differently different classes of water supplies. Those communities having sufficiently capacious ponds or reservoirs to store the whole amount of water flowing in the spring, obtained for use about the average yield of their sources of water supply; while those provided with smaller ponds or reservoirs, so that they could not prevent the spring flow of the streams from running to waste, felt much more severely the effect of the drought of the succeeding six months. The city of Boston practically exhausted the water in its Sudbury River reservoirs, but the fall rains fortunately came in season to prevent any shortage of water. Mystic Lake, which supplies Charlestown, Somerville, Chelsea and Everett, was reduced to so low a level that temporary pumps were used for a short time to pump water from the lake into the aqueduct.

These are only examples of what occurred in many places in the State. In the southern part of the State there was even less rain than in the eastern part, and some places, of which Southbridge and Uxbridge may be mentioned as examples, entirely exhausted the water from their usual sources of supply, and were obliged to resort to pumping water from the neighboring rivers, thus introducing into the pipes water of undesirable quality.

The State Board of Health was authorized and directed, by chapter 459 of the Acts of 1893, to investigate, consider and report to the Legislature of 1895 upon the question of a water supply for the city of Boston and its suburbs within a radius of ten miles from the State House, and for such other cities and towns as in its opinion should be included in connection therewith.

The experience of the past year has emphasized the urgent need of a new water supply for this district, as not only has the water supply of Boston and the district supplied from Mystic Lake been nearly exhausted, as above indicated, but the water supplies of a majority of the places in the Metropolitan district have been in a similar condition.

The Board began considering the subject of a water supply for the Metropolitan district seven years ago, by collecting information of a general character with regard to the various sources which might furnish a water supply for this district, and by determining the exact quality of the water of the different sources by a series of analyses covering a period of two years or more.

Owing to these preliminary studies, the Board was enabled to begin at once, after the passage of the act above mentioned, to enlarge its staff of engineers, and to make surveys and examinations with a view to determining definitely the capacity of different sources and the cost of obtaining a water supply from them.

While it is too early to present any conclusions regarding the best source of water supply for the district, it may be said that the investigations made up to the present time indicate that an abundant supply of good water for the Metropolitan district may be obtained without excessive expenditure.

The comparatively low stream-flow of the last three years has made the question of additional water supplies for many towns extremely urgent, and the advice of the Board as regards the capacity and fitness of new sources of supply has been repeatedly sought. The constantly increasing fund of information which the Board is acquiring through its staff of engineers, chemists and biologists, concerning the characters of the natural waters of the State, puts it in

position to give advice, in many cases, with a certainty and promptness that was not possible before these investigations were undertaken.

The chemical and microscopical analyses of the waters of the State have been continued during the year 1893, 1,731 samples of water having been examined. These examinations include many of the regular water supplies of the State, but a very much larger number of examinations than ever before has been made of waters proposed for new supplies of cities and towns.

Following is a classified list of the waters examined during the year: —

From open and covered reservoirs for the storage of ground waters,	26	
From ground-water supplies,	294	
Special investigations of regular water supplies affected by tastes, odors, etc.,	16	
From ponds and storage reservoirs and their inlets,	578	
From streams and miscellaneous sources,	127	
Total from regular water supplies,		1,041
In connection with investigations of new sources of water supply,	230	
With reference to pollution of streams,	155	
With reference to sewage purification at Framingham, Marlborough, Gardner, Medfield, Westborough, Lenox, Amherst and Wellesley,	251	
In connection with the study of epidemics,	18	
Miscellaneous,	36	
		690
Total,		1,731

The microscopic vegetable and animal organisms have been determined as usual in all the waters which have been examined chemically, and our knowledge of the connection between these organisms and the tastes and odors of the waters, has been somewhat increased.

The continued investigation of the efficiency of sewage purification throughout the State by the chemical and biological examination of sewages and effluents, and by the mechanical analysis of soils, has afforded important results, which, taken in connection with the experimental work at

the Board's Experiment Station at Lawrence, can be directly utilized in determining rules of practice for the purification of sewage by intermittent filtration on a large scale. A very large number of examinations of sewage and effluents has been made from the purification fields at Framingham, Marlborough, Gardner, Medfield, Westborough, Lenox and Wellesley. No sanitary question is of greater or more immediate importance than the disposal and purification on land, of the sewage of cities and towns. To do this effectively and harmlessly, an intelligent control of the process is needed for each situation.

In connection with the study of new sources of supply, a large number of ground waters has been examined, with the result of adding much to our knowledge of the subterranean waters of the State. In the report for 1892 attention was directed to the presence of iron in some ground waters, which made them very objectionable for domestic use. During the past year the metal manganese has been found in well waters at Watertown in considerable amount, associated with organic matter. The sanitary significance of this occurrence has yet to be determined.

In previous reports of the Board attention has more than once been drawn to the fact that the deeper layers of water in ponds were stagnant during the warmer months, and that when the bottom of the pond or reservoir contained decomposable organic matter the water near the bottom became very foul with the products of putrefaction. In the case of Lake Winnipiseogee, samples taken during August at a depth of 110 feet from the surface showed the water to be of the same quality and composition at the bottom as at the surface.

Analyses of soils from a proposed storage reservoir have been made to determine the amount of stripping which would be necessary to remove all the organic matter from the surface before filling the reservoir with water. The cleaning of the bed and sides of a reservoir is now known to be essential if the water contained in it is to be preserved free from putrefactive products in summer; but the depth to which the surface soil should be removed can be best learned by a direct determination of the organic matter in the different layers. The results of the analyses in this case are interesting and valuable.

An extended series of analyses of the water of the lower Charles River has been made during the year to determine the amount of its pollution by sewage and manufacturing wastes, and also to determine the influence of the flood tide in backing up the impure water.

During the year the artificial ice made for sale in the State has been investigated, chemically and biologically. A special report on the subject was made to the General Court on May 16, 1893.

Of the sewage filters at the experiment station, several of those that had been in use for five or six years had for a year or more been subject to treatment known to be unlikely to give the best results, but tried for the purpose of learning the result of peculiar methods of treatment, and the effluent was not as well purified as in former years. Upon restoring the old filters to their normal condition and treating them by the methods which had been found most favorable for complete purification they resumed their former ability, and gave as satisfactory effluents, both in quality and quantity, as in former years.

In the filtration of sewage remarkable results have been obtained through the past year, by first filtering sewage very rapidly (nearly five hundred thousand gallons per acre daily) through gravel stones through which air was also being constantly drawn; and then again filtering this effluent through sand at the rate of about one million gallons per acre daily. By the first filtering about 82 per cent. of the albuminoid ammonia and the same percentage of the bacteria were removed; and at the end of the second filtering there remained in the effluent but 2½ per cent. of the albuminoid ammonia of the sewage and but two one-hundredths of 1 per cent. of the bacteria. By this method of first burning up the sludge by the help of the current of air drawn through the gravel stones nearly three times as much sewage may be nitrified and purified with a given area of surface as has been previously purified by sand filtration.

It is desirable that experiments upon this method of filtration be continued and its limits determined.

Very good effluents have also been obtained by rapid filtration through sand of the supernatant liquid after sewage has

settled naturally and after the sludge has been precipitated by chemicals.

In water filtration very satisfactory results in the removal of bacteria have been obtained when filtering at much higher rates than formerly, even up to nine million gallons per acre daily. These results indicate the desirability of further experiments to determine under what conditions satisfactory removal of disease germs may be assured when filtering at more rapid rates.

ADVICE TO CITIES AND TOWNS.

Under the provisions of chapter 375 of the Acts of 1888, entitled "An Act to protect the purity of inland waters, and to require consultation with the State Board of Health regarding the establishment of systems of water supply, drainage and sewerage," the Board is required "from time to time *to consult with and advise the authorities of cities and towns, or with corporations, firms or individuals either already having or intending to introduce systems of water supply, drainage or sewerage, as to the most appropriate source of supply, the best practicable method of assuring the purity thereof or of disposing of their drainage or sewage, having regard to the present and prospective needs and interests of other cities, towns, corporations, firms or individuals which may be affected thereby.* It shall also from time to time consult with and advise persons or corporations engaged or intending to engage in any manufacturing or other business, drainage or sewage from which may tend to cause the pollution of any inland water, as to the best practicable method of preventing such pollution by the interception, disposal or purification of such drainage or sewage: *provided,* that no person shall be compelled to bear the expense of such consultation or advice, or of experiments made for the purposes of this act. *All such authorities, corporations, firms and individuals are hereby required to give notice to said Board of their intentions in the premises, and to submit for its advice outlines of their proposed plans or schemes in relation to water supply and disposal of drainage and sewage;*

and all petitions to the Legislature for authority to introduce a system of water supply, drainage or sewerage shall be accompanied by a copy of the recommendation and advice of the said Board thereon."

During the year 1893 the Board has given its advice to the following cities, towns, corporations and individuals who have applied for such advice under the provisions of the general act of 1888, or under special acts relating to water supply and sewerage.

Replies were made during the year to applications made from the following sources for advice relative to water supply: Arlington, Canton, Chester, Fairhaven, Falmouth Heights, Holyoke, Hyde Park, Kingston, Lawrence, Lexington, Lowell, Lynn, Marlborough, Medford, Melrose (three replies), Mendon, Methuen (two replies), Newburyport (two replies), North Andover, Peabody, Rockport, Salem, Saundersville (Grafton), Scituate, Sharon, Southbridge (two replies), South Deerfield, Stoughton, Uxbridge, Wakefield, Walpole (two replies), Waltham, Webster, Westborough, West Springfield, Whitman.

Replies relating to sewerage and sewage disposal were made in response to applications from the following sources: Andover, Attleborough, Braintree, Brockton (two replies), Framingham, Holyoke, Leicester (three replies), North Brookfield, Pittsfield, Plymouth, Spencer and Westborough.

Water Supply.

The following is the substance of the action of the Board in reply to applications for advice relating to water supply: —

Arlington. The committee on water supply of the town of Arlington applied to the State Board of Health, Dec. 24, 1892, for advice relative to the best method of obtaining a water supply for the higher portions of the town, which cannot be supplied from the present service, and of improving the quality of the present supply. The attention of the Board was particularly called to a plan for pumping water from driven wells, on the borders of the great meadows and near the East Lexington railroad station, to a reservoir at a

sufficient height to supply the high portions of the town. The Board replied as follows: —

BOSTON, Feb. 10, 1893.

In order to ascertain the quality of water from these wells, the Board has caused analyses to be made of the five samples sent in by you. These samples showed the presence of an unusually large amount of free ammonia for a ground water and a larger amount of iron than is commonly found, both of which were probably due to the proximity of the wells to the Great Meadows. Notwithstanding these characteristics, if the water drawn from this source should continue to be as good as the samples, there is no doubt that it would be satisfactory for all water-supply purposes, and very much better than the water at present supplied to Arlington. The great danger, however, is that with continued pumping the water will be derived to an increased extent from the meadow by filtration through the peaty material, and will deteriorate and become unsatisfactory.

It is obvious from an inspection of the locality where the wells are driven that very little if any water can come from the easterly or down stream side of the wells owing to the presence of rock and other impervious material, and the fall of the ground in this direction. In other directions from the wells the character of the upland which might contribute ground water to them is such that a large portion of the water flows off into the meadows, and only a comparatively small amount soaks into the ground, near enough to the wells so that it will percolate directly to them. If any large quantity of water is to be obtained from the wells, the supply must necessarily be derived from the meadow by the filtration of water through it into the ground beneath, and under such circumstances it is extremely doubtful if the supply will continue to be of satisfactory quality.

With regard to the quantity of water to be derived from this source, the character of the material encountered by the test wells and the results obtained by the pumping test seem to indicate that the ground in the immediate vicinity of the wells is of favorable character for obtaining a ground water supply. The tests have not been sufficiently extended, however, to determine from how large a territory wells at this place will draw water or how much water can probably be obtained from this source. Even if the wells should draw water from a very considerable distance, so that all the water now coming into the Great Meadows could be utilized, the average daily supply in a dry year could hardly be expected to exceed 200,000 gallons per day; but if the water filtering through the peaty material of the Great Meadows should prove to be of

satisfactory quality the supply might be increased by diverting into the meadows some of the water from the upper half of the main watershed, which would otherwise run to waste during the spring over the dam of the main reservoir.

Taking everything into consideration the Board is of opinion that the chances are against getting a satisfactory supply from the proposed source either as regards quantity or quality, though some of the doubts which now exist might be removed by more thorough tests of this source if it were thought advisable to make them.

In view of the unfavorable outlook for obtaining a satisfactory supply from the source already tested near the Great Meadows, the Board has caused examinations to be made by its engineer of other portions of the watershed from which your water supply is derived. Judging from the surface indications he finds that some of the land in the vicinity of the main brook which feeds your reservoir promises to furnish a larger supply of ground water of good quality than any other place upon the watershed, and the Board would therefore advise that you make further tests in this vicinity. It is desirable to locate a well or wells quite a long distance, say one-fourth of a mile or more, above the present reservoir but not so far up stream as to be above the ridge, through a cutting in which Munroe Brook flows into the stream which supplies your reservoir. It is also desirable to avoid the immediate vicinity of any large swamp, and to select a place where the porous material from which water can be pumped freely extends to a considerable depth, say from thirty to fifty feet.

In addition to the question of obtaining a supply from the ground your application also refers to the deepening of the present reservoir with a view to improving the quality of the water.

The disagreeable character of the water drawn from the reservoir at times last year and also on previous occasions is caused by the growth and decay of minute vegetable forms, and these in turn grow in greater abundance when the water contains an abundant supply of nitrogenous food. Experience has shown that this supply of food may be derived from organic matter in the bottom of the reservoir or it may come into the reservoir in the water which supplies it. In the present case the supply of food for these minute organisms may be derived from both these sources, as there is a considerable amount of organic matter in the bottom of the reservoir, and analyses show that the water of the brook entering the reservoir contains a liberal supply of nitrogen, a result which might be expected from the population upon the watershed and the heavy manuring of portions of it.

The removal of all mud from the reservoir and the deepening of

the shallower portions would undoubtedly have a decided tendency to improve the character of the water. Of these improvements, however, the removal of the mud is of greater importance than the deepening of the shallower portions of the reservoir where it has a gravelly bottom; still, both of them are very desirable. There can be no certainty, however, of any radical change for the better in the quality of the water, as these improvements would only remove one of the causes of the minute vegetable growths.

CANTON. The water commissioners of Canton requested the advice of the State Board of Health, March 29, 1893, as to the propriety of taking an additional supply of water from the valley of Beaver Brook. To this application the Board replied as follows: —

BOSTON, June 2, 1893.

The State Board of Health has considered your application with regard to an additional water supply, to be taken from the valley of Beaver Brook above your present pumping station, in accordance with the report of your engineer, submitted with said application.

The report above mentioned contains the results of investigations made at various points in the valley of Beaver Brook above the present pumping station. The nearest point at which the investigations indicated the existence of a valuable additional supply is half a mile above the present pumping station, in an extensive meadow and swamp lying above Pleasant Street. Other investigations were made about a mile above the pumping station in what are known as the Ponkshire Meadows and from this point up to the vicinity of the Henry Springs, so called, and the question of taking an additional supply from Dead Meadow Brook and from York Pond, which lies at the head of Beaver Brook, was also considered.

All of these sources except the Ponkshire Meadows may furnish a valuable additional supply in the future, but the investigations in the meadow above Pleasant Street indicate that a sufficient additional supply of good water for the present may be obtained from this source alone.

The plan proposed by your engineer to meet all present requirements consists of a large collecting well about 2,600 feet above the present well, and connected with it by means of a twelve-inch pipe laid at a considerable depth below the surface of the ground. It is also proposed by him to extend pipes above the new well and to connect driven wells with them to furnish additional water.

Ten test wells were driven in the immediate vicinity of the pro-

posed collecting well and at varying distances from it, and samples of water from a portion of these wells have been analyzed by the State Board of Health. The tests in this vicinity indicate the existence of porous layers beneath the surface, through which water will flow freely; and the samples of water collected in the immediate vicinity of the proposed collecting well were of excellent quality. At a distance of a few hundred feet from this location, however, one sample was collected which contained enough iron to make the water objectionable for domestic uses, and at a somewhat greater distance in another direction an unsatisfactory water was obtained. There is therefore some doubt whether the water at the location of the collecting well will maintain its present good quality when a continuous draft on the well causes the water to flow to this point from all directions. The tests above the collecting well are limited in number and do not enable any definite judgment to be formed as to the character of the water to be obtained from the wells, which, according to the proposed plan, are to be driven to supplement the supply from the collecting well.

Taking the investigations made in this vicinity as a whole, they seem to indicate that it will be feasible to obtain a satisfactory supply of water, but they do not indicate definitely how large a territory will furnish good water, or whether the territory which furnished samples of good water will continue to furnish water of the same quality when a continuous draft is made upon it, nor can the permanent quality of the water be thoroughly tested except by producing this continuous draft, which may be done either by driving wells, connecting them together and pumping from them for a long time, or by laying the proposed main pipe and connecting the driven wells with it so that they will flow continuously. The cost of a pumping test would be so large, without adding anything of permanent value to the works, that the Board advises the laying of the main pipe as proposed by your engineer, and the connection with it of driven wells, substantially as proposed by him, in the territory where the best water can be obtained, and one or two driven wells at the site of the proposed collecting well, but it would not advise the construction of the collecting well until the test wells in its vicinity had shown by running a long time, say six months or a year, that the water from them was not deteriorating in quality. After such test the collecting well could be constructed.

CHESTER. The committee on water supply of the town of Chester applied to the State Board of Health, April 25, 1893, for its advice relative to taking the water of Austin, Walker

and Blandford brooks, in the towns of Chester and Becket, and of Horn Pond in the town of Becket. The Board replied as follows: —

BOSTON, June 1, 1893.

In response to your application of April 25, 1893, the State Board of Health has caused an examination to be made of four sources of water supply for Chester, namely, the Austin, Blandford, and Walker brooks in Chester and Becket, and Horn Pond in Becket.

Samples of water from all of these sources, collected by you May 22, have been analyzed. All four samples are very soft and there is no choice between them in this respect. In all other respects the analyses of samples from the Austin and Blandford brooks indicate that these waters are very nearly alike in quality, with a slight advantage in favor of the Austin Brook, and that they are decidedly better than the waters of Walker Brook or Horn Pond. An examination of Austin Brook shortly after a heavy rain showed only a moderate amount of turbidity in its water, and the absence of houses and roads upon its watershed are a point in its favor. It is therefore a very desirable source of supply to the extent of its capacity. There is obviously no reason to doubt that it will furnish the town with an ample supply of water for all ordinary water supply purposes except during very dry seasons, and judging from the yield of other mountain streams, in proportion to the territory drained by them, it will furnish a sufficient quantity of water even at such times for these purposes.

The Blandford Brook at its mouth has a watershed about one-half greater than that of the Austin Brook, and in the absence of definite knowledge its summer flow may be assumed to be one-half greater than that of the Austin Brook.

The sample of water from the Walker Brook was, as before indicated, not as good as those from the Austin and Blandford Brooks; still it would be classed as a satisfactory water in towns where there are not so many opportunities for getting a first-class water, and there is no reason now known to the Board why it should not be resorted to should the other sources fail in very dry times to furnish a sufficient supply. At such times it seems probable that the water from this brook might be as good as that from the others, but more definite information upon this point can be obtained by collecting and analyzing a sample of water from the brook when at a low stage.

The sample from Horn Pond indicates that at the time of its collection the water of this source was better than that of the Walker Brook, but not nearly as good as that of the other brooks.

The water of ponds and other quiet bodies of water is liable to be affected at times by growths of minute organisms which affect the taste and odor of the water, and which, though not known to be injurious to health, may at such times render the water unpalatable. This source would furnish a sufficient quantity of water, but owing to the reasons above indicated and to the larger cost of taking water from it on account of its greater distance from Chester, it does not seem to be a desirable source for the town to adopt.

In the following suggestions as to the source to be adopted and the general plan of works the Board necessarily bases its judgment on facts deduced from observations made in other places, and these suggestions may therefore require modification on account of the local conditions affecting the minimum flow of these streams, of which the Board now has no definite knowledge. The suggestions are that Austin Brook should be adopted as a source of supply in any case, and that if a larger amount of water than it will supply is needed it should be taken from the Blandford Brook near its mouth. If a still further supply should ever be needed, which would occur only during very extreme droughts, if at all, it should be taken from Walker Brook. Should water be taken from both the Austin and Blandford brooks it would be desirable to place the inlet at the former slightly higher than at the latter so as to insure taking the supply from the Austin Brook whenever it will furnish a sufficient quantity of water, and thereby prevent the entrance of the water from the Blandford Brook whenever it is affected by the wash from the road near it.

FAIRHAVEN. The authorities of Fairhaven applied to the Board, March 10, for advice in regard to introducing a water supply from driven wells in the easterly part of the town, to which the Board replied as follows: —

BOSTON, May 5, 1893.

The State Board of Health has considered your application dated March 10, 1893, relative to a proposed water supply for the town of Fairhaven, to be taken from driven wells in the valley of the Nasketucket River, a small stream situated about one and a half miles east of the town. At this place six test wells have been driven and are now flowing. Samples of water collected from three of these wells have been analyzed. The analysis of the water from the northeasterly well showed it to be a very pure and very soft water, while the samples from one of the intermediate wells and from the southwesterly well indicated water that had at some time been polluted and again purified by filtration through

the ground. As there are very few houses anywhere near the wells and the whole watershed is very sparsely settled, the inference to be drawn from these results is that the southerly wells intercept a vein of water which has passed near one of the nearer farmhouses. These results should not lead to the rejection of this source on the score of quality, because, not only is the water purified by its passage through the ground, but it is not improbable that when water is pumped from this source continuously it will assume much more nearly the character of the water now flowing from the northeasterly well. It would be advisable, however, in any case, if a supply is taken from this source, to determine from which farmhouse the polluting matter now enters the ground, and prevent such pollution, rather than depend upon the purifying power of the ground.

With regard to the quantity of water to be derived from wells in this locality, the tests made up to the present time do not appear to be conclusive as to whether the supply will be sufficient for the town for any considerable time in the future. Taking into account, however, the results of these tests, the comparative economy of this source on account of its nearness to the town as compared with any source from which it is at all probable that a satisfactory supply can be obtained, the opportunities for supplementing the supply whenever necessary from the Mattapoisett River valley, and the excellent quality of the water which the proposed source may be expected to furnish with proper care to prevent pollution, the Board is of opinion that this source is a proper one from which to take at the present time a water supply for Fairhaven.

It has been found by experience in this State that wells encountering ledge within 20 to 30 feet of the surface do not furnish as large a quantity of water as where the ledge is at a greater depth, and the Board therefore advises you to make further tests of the ground in this vicinity before locating the permanent wells in order to ascertain if a place cannot be found where the ground is porous enough to furnish water freely and where the ledge is at a greater depth than at the present location.

FALMOUTH HEIGHTS. The Falmouth Heights Water Company applied to the Board, June 13, for advice relative to taking a supply of water from a well or wells on the premises of the company at Falmouth Heights, a summer resort in Falmouth, upon Vineyard Sound. The Board replied as follows: —

BOSTON, July 6, 1893.

In reply to your application dated June 13, 1893, relative to a proposed water supply for the summer settlement known as Fal-

mouth Heights, in the town of Falmouth, the State Board of Health has caused an analysis to be made of a sample of water from a well sunk in one of the parks at the Heights, a few hundred feet north of Observatory Hill, and finds that the water is at present of excellent quality for water supply purposes.

Without further information the Board is unable to advise in regard to the quantity of water that can be obtained, and it should be examined after continued use that its permanent character may be determined.

HOLYOKE. The water commissioners of Holyoke applied to the Board, June 13, for its advice relative to taking the water of Munn Brook, in the town of Granville, as an additional water supply for the city. The Board replied to this application as follows: —

BOSTON, Oct. 5, 1893.

The State Board of Health received from you on June 13, 1893, an application for advice with regard to an additional water supply for the city of Holyoke, accompanied by a plan for taking water from Munn Brook in the town of Granville, through a pipe 20 inches in diameter, to Ashley Pond, one of the present sources of water supply of Holyoke.

The Board has caused an examination of the watershed of Munn Brook to be made, also an analysis of a sample of water collected from the brook near the proposed point of taking.

These examinations indicate that the water is soft and naturally of very good quality; but it is at present polluted at a few points by the discharge of sewage into it.

This pollution should be stopped before the water is taken for use, and as an additional precaution it is desirable that the water should be diverted into Ashley Pond rather than be allowed to run directly from the stream through the pipes into the city.

The amount of water which this source will furnish with a 20-inch pipe connection to Ashley Pond is so limited that the Board would advise the use of a pipe not less than 24 inches in diameter; and even with a connection of this size, the brook will not furnish, in very dry seasons, a sufficient additional supply for any long term of years in the future if the city continues to grow as it has in the past, unless capacious storage reservoirs are built upon it or its branches.

Certain sites for reservoirs have been indicated, but the information furnished with regard to their character, capacity, and cost is too limited to warrant an opinion as to whether it is desirable to

construct them. It has been shown, however, that it is feasible to supplement the supply to be obtained from Munn Brook by a comparatively short connection from the Westfield Little River; so that if Munn Brook should prove insufficient, there may be an opportunity to obtain a further supply from this river.

The Board has also caused an examination to be made, in a general way, of other available sources, among which may be mentioned the Westfield Little River above referred to, and Bachelor Brook in Granby, both of which would furnish more water than Munn Brook; the former by gravity, and the latter by pumping.

Neither of the three sources which have been mentioned has such a distinct advantage over the others as to enable the Board to advise, with the information now available, as to which is the most appropriate source of water supply for Holyoke.

It is obvious that a further water supply for Holyoke is urgently needed; and in view of the fact that an adequate additional supply will necessarily require a large expenditure of money, the Board advises you to have made, as promptly as possible, with the assistance of an engineer skilled in water supply investigation, a much more thorough investigation of the available sources than has yet been made.

When this additional information is received, the Board will advise you further in this matter.

Accompanying this reply will be found a table of analyses of samples of water collected from various sources.

The water of streams varies so much from time to time that it will be advisable to have further analyses made as a basis for forming a judgment as to the relative quality of water from the different sources. The Board will cause these analyses to be made, if you will provide for collecting the samples.

HYDE PARK. The Hyde Park Water Company applied to the Board, May 26, for advice as to the propriety of increasing their present supply of water by the use of driven wells north of their present driven well system. The Board replied to their application as follows: —

BOSTON, June 14, 1893.

The State Board of Health has received and considered your application dated May 26, 1893, asking it to examine and report upon the quality of water from a new system of driven wells, located just north of the present driven well system in Hyde Park.

Samples of water have been collected and analyzed from three wells of this system, one being the well nearest the river, another

a well near the middle of the system, and a third the well farthest from the river. These samples were all collected by pumping with a hand pump. The water from the well nearest the river (well No. 5) gives the same indications of imperfect filtration which are characteristic of water from the starch factory well, though not to so great an extent. This water would not be of satisfactory quality for water supply purposes. The samples from the intermediate well and from the one farthest from the river (wells Nos. 14 and 36) resemble in character the water taken from your present driven well system five or six years ago and are of satisfactory quality. Just what the effect will be of continuous pumping from the wells which now furnish good water cannot be foretold with certainty. The general experience under these circumstances, however, is that the water will deteriorate. The Board would therefore advise that if you take any water from the new system of wells each well should be provided with a gate so that it can be shut off if it furnishes water of unsatisfactory quality, and frequent tests should be made to determine whether or not the water is deteriorating.

It is very desirable that in increasing your supply in the vicinity of your present pumping station water should be taken from the ground as far from the river as suitable porous material can be found.

KINGSTON. The water commissioners of Kingston applied to the Board, June 9, for its advice relative to increasing their water supply by taking the water of Jones River, in case their present ground-water supply should prove insufficient. The Board replied as follows: —

BOSTON, July 6, 1893.

The State Board of Health received from you on June 9, 1893, an application with regard to using water from Jones River this summer for an additional water supply if the supply from the present well and filter-gallery should prove insufficient.

The Board caused samples of water collected from Jones River at Kingston in October, 1887, and in February, 1890, to be analyzed, and these analyses indicate that the water has a rather dark color, owing to the drainage from swamps on the watershed, and that it would not be wholly satisfactory to the consumers either in taste or appearance. With regard to its relation to the health of the consumers it may be said that in a case like this a chemical analysis of the water is not a trustworthy guide. The experience of the Board has shown that a *running stream* which receives sew-

age above the point where the water is taken from it is one of the most dangerous sources of water supply; because, if the infection of any specific disease is turned into the stream, it is much more likely to be conveyed to the water works intake and thence to the consumers before it loses its virulence than if the sewage entered a large pond or reservoir where there is no current.

The advice of the Board is therefore that the town of Kingston should not use the water of Jones River even temporarily without first ascertaining by an actual inspection of the main stream and its tributaries that no sewage is turned directly into them; and it is the further opinion of the Board that this river is not an appropriate source from which to take a permanent water supply for Kingston.

LAWRENCE. Application was received from the Lawrence water board for information in regard to the results of filtration of the water supply of the city through the filter covering two and a half acres, built by the city during the past year at an expense of about $65,000.

The water supply is drawn from the Merrimack River about nine miles below the entrance of the sewage of the city of Lowell, and for many years typhoid fever had prevailed in Lawrence to the extent of three times the average of the cities of the State, and following six or eight weeks after its prevalence in Lowell.

Under date of December 5, the following reply was made: —

The filter bed built by the city of Lawrence under the advice and in accordance with plans of the State Board of Health, has been steadily purifying the water supply of the city since the twentieth of September.

When commencing to construct the filter, you were advised that "with such a filter, properly managed, the experiments of the Board of Health indicate that at least 98 per cent. of all of the bacteria of the river water will, under all circumstances, be removed." During the past two months the filter has been removing this percentage of all the bacteria of the river water, but this is not all that it accomplishes; it removes a large part of the organic matter of the river water and converts it to mineral matter, thus removing from the water the food material which the bacteria live upon, and the result is that the two per cent. of bacteria remaining after the water has passed through the filter find their condi-

tions of life so unfavorable that they decrease as the water goes on through the reservoir and through the distributing pipes, until when the water reaches the citizens there remains but one-half of one per cent. of the number of bacteria in the river water, that is, ninety-nine and one-half per cent. of all have been removed.

The experiments of the Board indicate that the small number remaining are of a few hardy kinds that are not known to be in any way injurious to health, and leave the strong probability that all disease-producing germs have been removed.

It will be a satisfaction to the citizens to know that while for the past five years the number of deaths by typhoid fever in Lawrence has averaged five for the month of October and five for the month of November, the number of deaths this year has been only one for each of these months.

LEXINGTON. The water company of Lexington applied to the Board, February 15, for its advice relative to an additional water supply, and the Board replied as follows: —

BOSTON, May 4, 1893.

The State Board of Health has considered your application, dated Feb. 15, 1893, asking the advice of the Board in regard to an additional water supply for the town of Lexington. This application was accompanied by the report of the civil engineer employed by you to make investigations for an additional water supply for the town, and by a plan prepared by him of proposed storage reservoirs on Vine Brook, above your present works. The attention of the Board was subsequently called by you to the covered gallery, built last year, for the collection of ground water, in the sandy plain near the village, and connected with your present ground water sources.

The report of your engineer relates to examinations for a supply from entirely new sources as well as to augmenting the present supply by additional works within the territory from which it is derived. The examinations for new sources were made in a westerly or north-westerly direction from the central village of Lexington, in territory from which the water drains toward the Shawsheen River in the town of Bedford, and extended to a point nearly two and a half miles from the village. The larger streams within this territory will not furnish directly a water of satisfactory quality for the purposes of a public water supply, and the smaller streams at the points where the water is good will furnish so little water that it would be difficult, if not impracticable, to obtain from them a sufficient quantity of water for Lexington. The test wells

driven under the direction of your engineer within this territory give unfavorable indications with regard to obtaining a satisfactory ground water supply from it.

The difficulty of obtaining a supply from any new source about Lexington, as indicated by the special examinations of your engineer in the territory mentioned, and a general examination of other possible sources, seems to warrant the adoption of measures for developing the present supply which might not be warranted if a much better source could be obtained within a reasonable distance from the town.

It is understood that your present ground water sources now furnish an ample supply of water during all but the dryer portions of the year, and that the reservoirs shown upon the plan submitted are intended to supply the deficiency at such times. The lower of the two reservoirs is considerably further up stream and about five times as large as the one proposed by you in 1891, and referred to unfavorably in the reply of the Board to you dated April 7th of that year. The present location is much better than the old one, but, owing to the fact that some of the land above the reservoir is cultivated, and that so small a quantity of water will flow into it owing to the limited size of its watershed, much care will have to be taken to maintain the water in a pure and satisfactory condition. In the preparation of the reservoir all soil and vegetable matter should be removed from its bottom and sides, and the shallow portions should be deepened. A liberal amount of land should be acquired around the reservoir for its protection, and suitable arrangements should be made to prevent any washings from manured fields from flowing into it. It would also be necessary to take proper measures to prevent any contamination of the water by the drainage from a large stable at the extreme upper end of the watershed.

The upper reservoir is less satisfactory than the lower one as it is shallow and has so small a watershed that the water would stand in it a very long time before being replaced by fresh water, and it would probably become unfit for use. If, therefore, you decide to increase the supply by storing the surplus water which flows off during the wetter portions of the year, the Board would advise that the upper reservoir should not be constructed and that the lower one should be enlarged as much as possible by locating the dam somewhat further down stream, and by excavating within the reservoir. The suggestion of your engineer that "some additional ground water might be brought into the pump well by laying an open-jointed sub-drain in the trench with the leading main from the reservoir, making the joints tight wherever the pipe passed

through a muck deposit," is one worthy of adoption should the portion of the pipe trench through the sandy land toward the proposed reservoir be found to furnish water freely.

An analysis has been made of a sample of water collected from your covered gallery near the village, and the water is at the present time of satisfactory quality for domestic use. At the time the sample was collected water was not being drawn from this source, and as its quality may change when there is a draft upon it you are requested to notify the Board when you begin to use it, and further examinations will be made.

LOWELL. The Water Board of Lowell applied to the State Board of Health, May 9, for its advice relative to taking an additional supply of water from the valley of River Meadow Brook in the south part of Lowell. The Board replied as follows: —

BOSTON, May 15, 1893.

Samples of water from driven wells in this locality were sent in to the Board by your engineer last autumn, and the water was then found upon examination to be of excellent quality for all the purposes of a public water supply. This portion of the city, however, is growing rapidly and in order to maintain the purity of the water, if a supply is taken from this source, the city should control the land for a considerable distance from the wells in all directions so as to prevent the construction of buildings near them, and should extend the sewerage system of Lowell so as to carry away from all buildings the sewage which might otherwise find its way by filtration through the ground into the wells.

The time within which you desire a reply is too limited to permit the Board to make sufficiently extended investigations to serve as a basis for an opinion as to the quantity of ground water which can be obtained from the valley of this brook within the limits of the city of Lowell, nor does such an opinion seem necessary at the present time when you are constructing extended works by which the capacity of this source can be tested.

LYNN. The mayor of Lynn applied to the State Board of Health, January 31, for its advice relative to taking the water of Saugus River and its tributaries as an additional supply for Lynn. The Board replied as follows: —

BOSTON, April 4, 1893.

The application is not limited to any particular portion of the river and its tributaries, but the attention of the Board has been

directed chiefly to the territory above Howlett's dam, to which the works of the Lynn water supply now extend. Above this point on the river are situated the towns of Wakefield and Reading which turn so much polluting matter into the streams as to render the Saugus River at this point an unfit source from which to take a water supply, unless the water is very thoroughly purified by filtration. This polluting matter enters Quannapowitt Lake and its tributaries and the streams which flow through Wakefield and enter the river below the town. If these polluted waters were diverted, those coming from the remaining portions of the watershed would be comparatively free from pollution by sewage.

No extended chemical examinations of these unpolluted sources have been made, with the exception of Pilling's Pond, but judging from an examination of the water at this season of the year and a few previous analyses, it seems probable that some of the water, particularly that from the river itself, would be unsatisfactory for water supply purposes, owing to the large amount of swampy land with which the water comes in contact, thereby making it very dark in color and giving it a peaty taste and odor.

Pilling's Pond is an artificial millpond made by flowing a meadow to a depth of four feet. The State Board of Health in 1888 advised the Revere Water Company that this pond was not a suitable source of supply for the towns of Revere and Winthrop, owing principally to the fact that if used as a principal source of supply it would necessarily be drawn very low in the summer. The water, however, is of fairly good quality considering the very small depth of the pond and it might be used by Lynn in connection with present sources until a better supply can be obtained.

There is a very large amount of flat land adjacent to the river between the dam at Montrose and Lake Quannapowitt and it seems not improbable that a valuable ground water might be obtained from this territory, although there are no means of determining at all definitely at the present time either the quantity or the quality of water which could be obtained. It is not improbable, however, that the quality of the ground water would be very much better than any surface water supply from this vicinity and the quantity may be as large as would be furnished by the surface water sources after excluding the polluted water of Lake Quannapowitt and the brook which receives the drainage of Wakefield.

The Board recognizes the gravity of the present situation of the Lynn water supply and would therefore advise that provision should be made at the earliest possible moment for supplementing the present supply with the best water which can be obtained from the Saugus River watershed.

In order to provide any other than a very temporary supply of potable water from the Saugus River valley, it is obvious that the works must necessarily be somewhat complex and expensive, and it is not at all probable that a fairly permanent supply can be obtained from this source. The Board would therefore advise that before entering upon any extensive works in this valley, the whole subject of a further water supply from this valley, and from other available sources, should be carefully investigated. One of the first points in such an investigation should be the examination of the territory near the river, between the Montrose dam and the next dam above, with a view to obtaining a ground water supply.

The Board has now before it an application from the Wakefield Water Company, asking for advice with regard to an additional water supply for the towns of Wakefield and Stoneham, to be taken from filtering galleries, wells or basins, upon the banks of that portion of the Saugus River lying within the limits of the town of Wakefield, above the milldam at Montrose. The Board is aware of the fact that the Wakefield Water Company has practically reached the limit of capacity of Crystal Lake, its present source of supply, and that the other source, viz., Lake Quannapowitt, from which the water company was originally authorized to take a further supply, is not of suitable quality for water supply purposes. It is therefore of opinion that the right of Lynn to take water from the Saugus River valley should be so far restricted as not to prevent these towns from receiving from it as much water as may be needed for their supply, in addition to the quantity of water which Crystal Lake will furnish.

It is not feasible from present information as to the amount of water which can be obtained from different places, to make a fair apportionment of the territory between Lynn and these towns; the Board therefore concludes that Lynn should be granted the right to take water from any portion of the valley of Saugus River, not already granted by the Legislature to some other town or water company; but that this grant should be subject to the restriction that the towns of Wakefield or Stoneham, or the company supplying them with water, may be authorized to take water from this valley at any point within the limits of the town of Wakefield, and to the extent required to furnish in connection with Crystal Lake, the present source of supply, a supply of water for these towns. In connection with this restriction it would, of course, be fair to provide that whenever these towns, or the company supplying them with water, take a supply from any source in the Saugus valley other than those already controlled by the Wakefield Water Company, they should be required to pay to the city of Lynn a fair

proportion of the amount already paid by said city for water or land damages, and if they should utilize to any extent works previously constructed by the city, they should pay a fair proportion of the cost of these works.

The Board thinks it proper that a further application should be made for its advice when you can define more specifically the sources from which it is proposed to take water, and have by preliminary surveys and estimates obtained the facts which are essential as a basis for a proper decision as to the relative merits of different sources. With this further application in view the Board will co-operate with you by causing analyses to be made from time to time of the water of the various proposed sources.

MARLBOROUGH. The water commissioners of Marlborough applied to the Board, April 28, for its advice relative to constructing a new storage reservoir upon Millham Brook in the west part of Marlborough, near the Northborough line, and as to the probable quality of the water of such proposed reservoir at the end of eight years. The Board replied as follows: —

BOSTON, July 8, 1893.

The State Board of Health has carefully considered your application, dated April 28, 1893, with regard to constructing at once the proposed storage reservoir on Millham Brook in the vicinity of your new pumping station. You state in your application that you will not need the proposed reservoir for eight years or so and that you wish for the advice of this Board as to the probability of obtaining good water from this proposed reservoir after being flowed fifteen feet deep for a period of eight years without removing any of the soil.

A careful examination of the experience with all artificial reservoirs in the State which have not had the soil removed from them and which in other respects are at all comparable with the proposed Marlborough reservoir shows that in some of these reservoirs the water was bad every summer, not only for eight years after they were first filled but for a much longer time. A typical instance of a reservoir of this kind is the Ludlow reservoir at Springfield which was used for sixteen years and then practically abandoned for a new source of supply. Other reservoirs somewhat similar in character, although they may have furnished bad water when first filled, soon began to improve, and at the end of five, eight or ten years furnished very much better water than at first. The chances as to whether the water will continue to be bad or will improve materially at the end of eight years seem to be about even.

The experience with reservoirs which have been thoroughly cleaned by the removal of all soil and vegetable matter from their bottom and sides, although somewhat limited, has been extremely favorable, and from our present knowledge we should expect much better results from a thoroughly cleaned reservoir soon after it is filled than from an uncleaned reservoir eight years after filling.

The Board recognizes that the element of cost is an important factor in determining what should be done, and as the Board has no accurate information upon this point it cannot now advise definitely as to what should be done in the matter of constructing the reservoir. It would advise, however, that a careful estimate of the cost of thoroughly cleaning the reservoir should be made and would urge the adoption of this method of construction if it is found to be practicable.

MALDEN, MEDFORD AND MELROSE. For many years these suburban places have used Spot Pond as a source of water supply, but owing to the rapid growth of these communities the pond was drawn to a much lower level at the end of 1892 than ever before. The city of Malden has for several years taken a supplementary supply from driven wells in the easterly portion of the city, but the other two places were at this time wholly dependent upon Spot Pond for water. On Feb. 9, 1893, the Board addressed the following communication to each of the water boards of Malden, Medford and Melrose, with reference to the present condition of Spot Pond, and its capacity for future supply: —

BOSTON, Feb. 9, 1893.

The State Board of Health has on several occasions since the spring of 1889 considered applications for advice with regard to additional water supplies for the three communities now using the water of Spot Pond, and in considering these questions the engineers of the Board have given much attention to the probable yield and capacity of this source.

Some figures with regard to the probable condition of this pond during the year 1893 have been made in connection with a recent application for advice from the city of Medford, and as they may be of interest at the present time they are sent to each of you. The data used are the area of the watershed as determined by a reconnaissance upon the ground, sketching the watershed upon the new State map and measuring from it, the storage capacity of the pond as determined from the best maps now in existence; also the records of the yield of the watershed of Sudbury River, which

has been carefully measured by the city of Boston for the past eighteen years.

It has been found by applying these data for many years in the past that the results agree well with the known facts, and they may therefore be looked upon as the best basis at present available for determining what may be expected in the future.

We are informed that the pond on the first day of February was 143.5 inches below high water mark, which, by the tables showing the storage capacity of the pond, would indicate a draught from high water mark down to this level of 731,000,000 gallons.

The following table shows for purposes of comparison the storage in the pond from high water mark down to the present and lower levels.

Distance below High Water Mark, in Feet.	Storage in Gallons.
11 ft. 11½ in.,	731,000,000
15 ft.,	837,000,000
20 ft.,	962,000,000
Bottom of pond,	1,077,000,000

In making estimates as to what changes may be expected during the remaining months of 1893, the average consumption is assumed to be 600,000 gallons per day for each community, making a total of 1,800,000 gallons per day. It is found convenient to divide this period into two parts, including in the first one the months of February, March, April and May, during most or all of which the pond may be expected to rise, and in the second the remaining months, when under ordinary conditions it would lower, it is obvious that it is impossible to predict exactly what will happen, but it is fair to assume that the amount of water collected will not be greater than the maximum amount during the past eighteen years, nor will it be less than the minimum amount. It is more likely to be the average amount than any other quantity, but in as important a problem as the water supply of upwards of 50,000 people, provision should be made to avoid a water famine under the most unfavorable conditions which can exist.

It is found that on June first the deficiency of storage (meaning by this term the amount of water that would be required to fill the pond to high water mark) under maximum, average and minimum conditions of yield from February 1 to June 1, 1893, would be as follows: —

Condition of Spot Pond on June 1, 1893.

	Deficiency of Storage.
Maximum yield, ...	331,000,000 gallons.
Average yield, ...	490,000,000 "
Minimum yield, ...	677,000,000 "

For the period from June 1, 1893, to Jan. 1, 1894, it is obvious that regardless of the height of the pond on June 1 the amount of water going into the pond may be either the maximum, average or minimum, and the following tables show the deficiency in storage on Jan. 1, 1894, under all of these conditions.

(1) Assuming the deficiency in storage on June 1 to be 331,000,000 gallons, the deficiency on Jan. 1, 1894, will be as follows: —

	Deficiency.
Maximum yield, ...	172,000,000 gallons.
Average yield, ...	535,000,000 "
Minimum yield, ...	692,000,000 "

(2) Assuming the deficiency in storage on June 1 to be 490,000,000 gallons, the deficiency on Jan. 1, 1894, will be as follows: —

	Deficiency.
Maximum yield, ...	319,000,000 gallons.
Average yield, ...	685,000,000 "
Minimum yield, ...	841,000,000 "

(3) Assuming the deficiency in storage on June 1 to be 677,000,000 gallons, the deficiency on Jan. 1, 1894, will be as follows: —

	Deficiency.
Maximum yield, ...	494,000,000 gallons.
Average yield, ...	863,000,000 "
Minimum yield, ...	1,018,000,000 "

The most important conclusions to be drawn from the tables are, first, that with the average conditions from now until next January the pond will be at substantially the same level as at the same time this year; second, that if either one of the periods into which the year has been divided furnishes the average quantity of water and the other furnishes the minimum quantity, the water in the pond will be reduced to the 15-foot mark; and lastly, that if the yield for both of these periods should be a minimum the pond will be drawn practically to the bottom.

All of these estimates are based upon an average draught of 1,800,000 gallons daily from the pond, but it is doubtful if the draught can be kept as low as this without supplementary supplies

to furnish a portion of the water used. It is probable that a larger draught than the amount above given has had an influence in lowering the pond during the past year. The net loss of storage from the pond from Feb. 1, 1892, to Feb. 1, 1893, was 338,000,000 gallons. The same loss in the next twelve months would take all of the water out of the pond.

Not only should the conditions for the remainder of the present year be considered but the conditions which will exist subsequently until the time when a permanent supply is introduced should be considered, and it is therefore of the utmost importance that measures should be taken immediately, by providing supplementary sources or by making arrangements with some community which has water to spare, to get as much water into the pond as possible, or, what is the same thing, to take less water from the pond so as to have a larger supply in the pond to provide for the future contingencies, such as a rapidly growing population and supplementary supplies which may become unsuitable for domestic use. Every million gallons of water which can be added to the pond has a distinct value to the three communities now depending upon this source, which is much in excess of the mere cost of pumping the water, and it would be a benefit to all of the communities if a fixed price were made per million gallons of water, which should be charged to each community drawing more than a certain defined quantity and credited to any community taking from the pond less than this amount. This would offer an incentive for individual action on the part of those places which now have or can provide supplementary sources of supply and would not be unjust to any town that may be unable to obtain a supplementary source, as this town would only pay to the others what it would save in the cost of constructing and maintaining a pumping plant.

MEDFORD. The water commissioners of Medford applied to the Board, Jan. 4, 1893, for its advice relative to taking an additional water supply from wells west of Forest Street in Medford. The Board replied as follows: —

BOSTON, Feb. 2, 1893.

The State Board of Health has considered your application in regard to an additional water supply to be taken from driven wells in the flat open land west of Forest Street, where test wells have already been driven.

The Board has caused analyses to be made of samples of water taken from these wells and finds that it is a water which has at

some time been polluted, but which has been very thoroughly purified by its passage through the ground. The water as it now comes from the ground would be entirely satisfactory to the consumers as a drinking water, but it is much harder than the Spot Pond water and therefore would not be as good for washing purposes and for use in boilers. The hardness of the water, however, is not as great as that of several water supplies which are now in use in this State, and if the quality of the water remains as at present it would be satisfactory for the purposes of a public water supply. The situation of the test wells, however, is such that it seems probable that when a continuous draft is made upon the ground the water will be drawn in part from the territory south of the wells where there is a large population, and the water will become harder than it is at present, and it may be less perfectly purified; moreover, even if a large tract of land is purchased and controlled by the city for the protection of a water supply at this place the growth of the city will undoubtedly cause a material increase of population upon adjacent land, which contributes a portion of the water to supply the wells, and the character of the water may be further unfavorably affected in this way.

The Board would not therefore advise the construction of works for taking a permanent supply from this place, but in view of the necessity for supplementing the supply from Spot Pond, advises that this is a suitable source from which to obtain a temporary supply. The quantity of water to be obtained from this source is, with the present information, somewhat indefinite. It seems very doubtful if the source can be depended upon to furnish more than from 250,000 to 400,000 gallons per day continuously, though it is not impossible that during the wetter portions of the year a considerably larger quantity of water might be obtained.

In addition to the driven wells there is another source from which a temporary supply might be obtained, viz., the stream which flows just west of Forest Street, below where Elm Street joins it. Above this point there are very few houses or other sources of pollution upon the watershed, the area of which as measured from the State map is 0.58 square mile. An analysis of the water recently made shows that it is at the present time of suitable quality for water supply purposes, except that before being pumped it should be stored in a reservoir sufficiently large to permit the floating particles which are almost always found in brook waters to settle. During several months of an ordinary year the flow of this stream should be as high as 600,000 gallons per day, and during two months or more of such a year it should range from one to two million gallons per day. This source has the advantage that

it is very near the main pipe which leads to the town, and the water would have to be lifted to a less height to force it into the main. It is obvious, however, that in order to make it of value in the present emergency the works should be constructed at once so as to take advantage of the larger amount of water which flows in the spring of the year, as the amount of water to be obtained from this source in the summer would be comparatively small. The water would also be soft and suitable for laundry and boiler purposes, though not as palatable as that taken from the ground.

The choice of these two sources or whether both of them shall be utilized is a question which is left for your decision. The Board, however, considers it imperative that a supplementary supply or supplies should be provided at once by the communities using the water of Spot Pond in order to avoid a water famine during the next autumn and winter.

The results of certain computations with regard to the future condition of Spot Pond and a suggestion as to measures which should be taken to prevent the supply from being exhausted are embodied in another communication, a copy of which will be sent to you and to the water boards of Malden and Melrose. (See pages 28–31, preceding.)

MELROSE. The committee on additional water supply of Melrose applied to the State Board of Health, Dec. 5, 1892, for its advice as to the propriety of taking, either alone or in conjunction with Malden and Medford, the waters of Great Pond, in North Andover, together with Mosquito Brook and Boston Brook in the same town, as additional sources of water supply. The Board replied to this application as follows:—

BOSTON, Jan. 16, 1893.

In your application of Dec. 5, 1892, giving notice of your intention to provide an additional water supply for the town of Melrose and asking the advice of the Board in regard thereto, you make the following statement: "The plan proposed is, alone or in conjunction with the cities of Malden and Medford or either of them, to obtain authority from the Legislature to take and hold the waters of Great Pond in North Andover, and to acquire by purchase or otherwise the waters of Mosquito Brook and Boston Brook in said town of North Andover."

The State Board of Health has up to the present time received no applications relating to these sources from the cities of Malden or Medford and therefore considers only the first alternative, viz., a supply for Melrose alone.

Great Pond only has been investigated by the Board up to the present time, and it is found from this investigation and analyses of the water of the pond that the water is of satisfactory quality for all the purposes of a public water supply and that the quantity of water which the pond will furnish will be more than sufficient for the probable population of Melrose for the next thirty years.

Owing to the fact that the pond is situated wholly within the town of North Andover the Board is of opinion that this town has a primary right to so much of the water of the pond as is necessary to supply its inhabitants with water.

With regard to the appropriateness of this source for a water supply for the town of Melrose, the Board thinks it highly probable that a sufficient supply of good water for the town can be obtained at a less distance than sixteen miles and with less expense; and for this reason, and having regard for the interests of other communities much nearer Great Pond, which may in the future need its waters as a source of water supply, the Board advises the town to make examinations of nearer sources, and until such examinations are made is unable to advise that this is the most appropriate source of supply for the town of Melrose.

The Board will investigate the other sources mentioned in your application and advise you with regard to them as soon as practicable.

On February 3 the Board transmitted the following further communication upon the same subject to the committee on additional water supply of Melrose: —

BOSTON, Feb. 3, 1893.

The State Board of Health in its communication of Jan. 16, 1893, to your committee, relating to an additional supply of water for your town from Great Pond in North Andover, stated that further advice would be given with regard to the other sources mentioned in your application, viz., Mosquito and Boston brooks.

The application apparently relates to so much of these brooks as lies within the limits of the town of North Andover. The areas of the watersheds of these brooks above the points where they cross the town boundary, as measured from the topographical map of the State, are respectively 7.51 and 6.36 square miles, and their distances at these points in an air line from Melrose are 14½ and 12½ miles. These watersheds have been examined upon the map above mentioned, and upon the ground by one of the engineers of the Board, and they were not found to have any special characteristics which would make them as a whole particularly appropriate as sources of supply for Melrose or as desirable as other watersheds nearer the town.

It has been learned from statements made by a member of your committee and by your engineer, that it is proposed to utilize only so much of the upper end of these brooks as can be diverted by gravity through a ditch or canal along the side hill into Great Pond. In this case the area of watershed to be utilized is, according to the map above mentioned, in the neighborhood of three square miles instead of the total of about fourteen square miles above the town boundary. The three square miles are sparsely populated so that there is little danger that the water will be polluted, but there are swampy areas which give the water of the larger (Boston) brook a high color which would be objectionable if the water was to be taken directly into the pipes. If, however, this water is diverted as proposed into Great Pond its color will nearly disappear by long storage and by mingling with the nearly colorless water naturally in the pond.

The Board is of opinion that the town should not seek to acquire rights to the whole of Mosquito and Boston brooks within the town of North Andover, as the portions not available for diversion into Great Pond may be needed in connection with water supplies from the Ipswich Valley for other places in the eastern part of the State. If, however, the town of Melrose should be granted the right to take the waters of Great Pond it is appropriate that it should also be granted those portions of Mosquito and Boston brooks which can be diverted by gravity into it.

The water board of Melrose applied to the State Board of Health May 16, for its advice as to taking an additional water supply from wells to be driven in the meadow upon the north side of Ell Pond, and on July 5, the committee on additional water supply applied for advice with reference to taking water from other sources. The Board replied to these applications as follows:—

BOSTON, Aug. 10, 1893.

The State Board of Health received from the Melrose water board on May 16, 1893, an application for its advice relative to a proposed additional system of water supply to be taken from the ground on the north side of Ell Pond. On July 5 a second application was received from the committee on additional water supply for advice relative to taking a supply from Martin's Meadows, so-called, from Bennett's Pond or Meadows and from the Wakefield Water Company. On July 5 the last mentioned application was amended by adding Long Pond and its immediate vicinity to the sources before mentioned.

Before considering these sources in detail it will be well to refer in a general way to the capacity of your present source of supply, Spot Pond, and to the needs of your town.

Spot Pond during a year of average rainfall will supply to each of the communities taking water from it about 630,000 gallons of water per day; and, during a series of dry years, such as have occurred in the past, will furnish about 500,000 gallons per day to each community without falling to a lower level than it reached in February, 1893. With the pond at its present low level it cannot be depended upon to furnish even 500,000 gallons per day to each community if the next two or three years should be unusually dry. The consumption of water in Melrose by the meter records from September, 1892, to June, 1893, inclusive, averaged 565,000 gallons per day, which is 65,000 gallons in excess of the safe capacity of the pond for a series of dry years, even assuming it to have been filled in the spring, and still more in excess of its capacity in its present low condition. It is obvious, therefore, that to meet even the requirements of the present and the very near future it will be necessary to provide an additional source of supply or to decrease the consumption of water.

The consumption of water in Melrose at the present time is about 57 gallons per inhabitant, which is more than the amount used by most towns similarly situated. As instances of low consumption per inhabitant may be mentioned: Brockton, 25 gallons; Middleborough, 26 gallons; North Attleborough, 26 gallons, and Fall River, 26 gallons. On the other hand, Beverly uses 70 gallons, Braintree 62 gallons, and Brookline 80 gallons. During the period from September, 1892, to June, 1893, inclusive, Malden used 50 gallons and Medford 48 gallons per inhabitant.

It seems highly desirable that Melrose should take energetic measures to restrict waste, but in view of the fact that the present demands upon Spot Pond so largely exceed its capacity, and having regard to the present low state of the pond and the greater demand for water from year to year, due to the increasing population, the Board is of opinion that a further supply should be obtained without delay.

The great expense to which Melrose would be subjected if it should attempt to obtain by itself a permanent supply of water, which can only be had from a comparatively great distance, the fact that the Legislature has already directed that investigations be made with a view to obtaining a water supply for Boston and its suburbs, and the need of an immediate addition to the present supply, all lead to the conclusion that it is wise to obtain at a comparatively small cost a temporary supply which will meet the

requirements for the next five or six years. Should any of the sources mentioned by your committee be adopted, they should be considered merely as temporary sources which will have to be abandoned whenever the quality of the water becomes impaired by the growth of population upon the territory from which the supply is derived or by other causes, or whenever a more satisfactory and permanent water supply is introduced.

Of the sources mentioned by the committee it may be said that the water of Bennett's Pond, if taken directly from the pond, would not be of suitable quality on account of the large population near the upper portion of the brook which feeds it. With regard to a ground water from the vicinity of Bennett's Pond, no definite answer can be given because no investigations of the ground at this place have been made. It is not improbable that the quality of the water would be good, but, judging from the surface indications, this source could hardly be expected to furnish a sufficient quantity of water to make it a desirable one to adopt at the present time.

Long Pond by itself would not furnish a sufficient quantity of water to warrant taking an additional supply from it, and if a stream which flows near its westerly end should be diverted into it the quality of the water would not be satisfactory if taken directly from the pond. With regard to obtaining a ground water supply in this vicinity no investigations of the ground have been made, but, judging from surface appearances, the conditions are even less favorable than in the vicinity of Bennett's Pond.

The Wakefield Water Company now takes its supply from Crystal Lake, and the water is of suitable quality for the purposes of a public water supply. The quantity of water which this source will furnish in a series of dry years is but little, if any, in excess of the present requirements of the two towns now supplied by the Wakefield Water Company, and the only water which this company has to spare is the excess, during years of average or high rainfall, above the requirements of the two towns now supplied. The Board, therefore, does not advise the town of Melrose to depend upon the Wakefield Water Company for its additional supply. On the other hand, it is extremely important as a precaution against a water famine in the next few years that Spot Pond should be again filled, a result which can be accomplished if each of the communities now drawing water from the pond should obtain the greater part of its supply from some other source or sources; and it may therefore be desirable, if suitable arrangements can be made, to have the Wakefield Water Company supply as much water to Melrose as the capacity of its source will permit.

A sample of water collected from Whittier's wells in Martin's Meadows, so-called, on July 20 showed that the water obtained from the ground at this place was of satisfactory quality for the purposes of a public water supply, and from an examination of the premises it seems probable that this water will remain of suitable quality for use, at least until there is a further increase of population in this vicinity. The quantity of water which this source will furnish is apparently limited, and it is extremely doubtful if it alone will furnish a sufficient additional water supply for the town. Samples were also received from wells in the meadow above the one already mentioned, but the water from these wells was not of satisfactory quality to pump directly into the pipes.

The territory just north of Ell Pond has been tested in several places. The first test was made in January, 1893, by pumping from a line of driven wells very near the pond. This test lasted for fifteen days and the average quantity of water pumped is said to have been about 461,000 gallons per day. Three samples of water from these wells were sent to this Board for analysis. One was taken at the beginning of the test, another a week later, and the third at the end of the test. All of these samples were clear and colorless and free from odor, and, although they all showed, by the greater amount of mineral matter and hardness than the natural waters of this region, the effect of the population upon the territory from which the supply is derived, the analyses also show that the water had been very thoroughly purified by its passage through the ground.

Three additional samples taken from this vicinity in June and July, 1893, gave results which confirmed those above mentioned, the analyses showing that in every case the water had been completely purified, chemically, by its passage through the ground. The wells from which two of these last mentioned samples were taken were 175 feet from the pond, while the third sample was taken from one of the line of wells near the pond. A bacterial examination of a sample of water from one of these wells showed that the water was of good quality, bacterially.

There seems to be no doubt that the quantity of water which can be obtained from the ground in this vicinity is greater than from any of the other sources mentioned, and the principal question which arises with regard to this source is as to whether the water will remain of suitable quality for use after long-continued pumping. The principal source of danger is that the water of the pond, which is highly polluted, will find its way through the ground to the wells without being thoroughly purified by filtration. Ex-

perience has shown in some cases that water may filter from a pond to wells or to a filter-gallery and under some conditions be thoroughly purified by its passage through the ground, and yet under other conditions fail to be purified. It is impracticable to predict in the present case whether the water drawn from the ground will deteriorate in quality from this cause. Taking into account, however, the urgent needs of your town and the difficulty of obtaining a sufficient quantity of water from a better source, the Board would advise that this location be adopted as a source of supply, but with the understanding that the works are to be of a temporary character and that the water is to be analyzed frequently and its use discontinued if it should become impure. The wells should be located not less than 175 feet from the pond and further from it if practicable.

On Feb. 9, 1893, the Board sent a communication to the water boards of the three places drawing water from Spot Pond; and, after giving the results of estimates as to changes in the level of the pond which would be likely to occur under varying conditions of rainfall, the Board ended its communication with the following statement, to which it would again call attention: —

It is of the utmost importance . . . to get as much water into Spot Pond as possible, or, what is the same thing, to take less water from the pond so as to have a larger supply in the pond to provide for future contingencies, such as a growing population and supplementary supplies which may become unsuitable for domestic use. Every million of gallons of water which can be added to the pond has a distinct value to the three communities now depending upon this source, which is much in excess of the mere cost of pumping the water, and it would be a benefit to all of the communities if a fixed price were made per million gallons of water, which should be charged to each community drawing more than a certain defined quantity and credited to any community taking from the pond less than this amount. This would offer an incentive for individual action on the part of those places which now have or can provide supplementary sources of supply, and would not be unjust to any town that may be unable to obtain a supplementary source, as this town would only pay to the others what it would save in the cost of constructing and maintaining a pumping plant.

MENDON. The selectmen of Mendon applied to the Board, Dec. 27, 1893, for its advice relative to taking the water of Mendon Pond as a public water supply. The Board replied to this application as follows: —

BOSTON, Jan. 5, 1894.

The Board has already considered the question of the use of this pond as a source of water supply, in response to an application

made by the town of Uxbridge in 1892, and has caused analyses of the water to be made in October, 1892, and every month from May to November, 1893. During all of this time the water has been of satisfactory quality for all the purposes of a public water supply, and there seems to be no reason to doubt that if it is protected from pollution it will continue to be of satisfactory quality in the future.

Owing to its situation near the village of Mendon it is an appropriate source from which to take a supply of water for the village and any part of the town to which it may be desirable to extend the pipes.

The amount of water required for the supply of Mendon will not be large, and in the opinion of the Board the use of the pond as a source of water supply for Mendon should not prevent its use as a source of water supply by Uxbridge.

METHUEN. The water commissioners of Methuen applied to the Board, April 13, 1893, for advice as to obtaining a water supply for the town from driven wells near Sargent's Brook in the east part of the town. The Board replied as follows: —

BOSTON, May 19, 1893.

The State Board of Health has considered your application of April 13, 1893, relative to a proposed water supply for the town, to be taken from driven wells near Sargent's Brook, and has caused examinations of the premises and analyses of the water to be made.

The analysis of a sample of water sent in from one of the flowing wells showed the water to be very pure and soft, and in all respects an excellent water for the purposes of a public water supply. After pumping for nearly six days, however, from these wells another sample was collected, and the character of the water was found to have undergone a decided change and to be much less satisfactory. Should this deterioration continue with steady pumping, as has been the case in some other places in the State, the water would become objectionable.

The watershed above the point where the wells are located was examined and its area determined approximately by sketching its outlines upon the topographical map of the State, and subsequently measuring it. This area was found to be so small that the *total* amount of water flowing from it, through the brook and through the ground, in a dry year would not be in excess of the requirements of a water supply for Methuen, having due regard to future

needs. It was obvious from an examination of the watershed that much of the water would flow off through the brook, particularly in the spring of the year, so that the supply to be obtained from the ground would be much less than the total flow from the watershed, and probably not enough during the dryer portions of a dry year to supply the town as soon as water is generally introduced.

On July 5 the water commissioners of Methuen again applied to the Board for its advice upon the question of taking a water supply for the town from wells driven near the Spicket River at the junction of the brook leading from Harris Pond. The Board replied to this application as follows: —

BOSTON, July 25, 1893.

In response to your application of July 5, 1893, with regard to a proposed water supply for the town of Methuen, to be taken from driven wells located near the Spicket River near the point where it is joined by the brook leading from Harris Pond, the Board has caused an examination of the locality and an analysis of a sample of water sent in by you from one of these wells to be made. The analysis showed that the water sent in was of excellent quality for the purposes of a public water supply. Judging from the tests made under your direction, and from an examination of the territory in the vicinity of the test wells, it is probable that a sufficient supply for the town for at least a few years may be obtained from the ground near where the tests have been made, and this location has the great advantage that it is well situated for taking a supplementary supply of water from Harris Pond whenever the quantity of water which can be obtained from the ground proves insufficient.

NEWBURYPORT. In the report of the State Board of Health to the Legislature, dated Jan. 10, 1893 (Senate Document 4, 1893), it was stated that the water of the Merrimack River had been furnished directly to the citizens of Newburyport by the Newburyport Water Company, and that a letter had been sent to the Newburyport Water Company, November 3, informing them that the water of the Merrimack River was unfit for domestic use, and advising them to obtain a further supply of pure water without delay. This advice having been disregarded by the company, an epidemic of typhoid fever took place in January and February, 1893, among the citizens of Newburyport. The Board then ad-

dressed the following communication to the mayor of Newburyport: —

BOSTON, March 3, 1893.

To the Mayor of Newburyport.

DEAR SIR: — On the 3d of November, 1892, having learned that the Newburyport Water Company had at times pumped the water of the Merrimack River and distributed it to the citizens of Newburyport, the State Board of Health addressed the following letter to the company: —

The Board, as a result of extended examinations of the effect of using the Merrimack River water at Lowell and Lawrence, reached the conclusion that it is to this cause that the excessive mortality from typhoid fever in these cities, as well as the very severe epidemic of this disease in the winter of 1890-91, may be ascribed. The condition of this river at Newburyport is worse than at either Lowell or Lawrence, owing to the added sewage of the cities of Lawrence and Haverhill, and the town of Amesbury.

In view of this condition of affairs, the Board is of opinion that the Newburyport Water Company should obtain a further supply of pure water without delay, so that there will be no further occasion for pumping water directly from the river.

In the Twenty-second Annual Report of this Board, page 527, it was shown that the introduction of a pure water supply into Newburyport in 1881 was followed by a reduction in the death-rate from typhoid fever of more than one-half.

It now appears from an investigation recently made by this Board that the frequent pumping of a considerable quantity of the water of the river has been followed very closely by an epidemic of typhoid fever among your citizens. This epidemic, in the opinion of the Board, is due to the use of the river water, following an increased prevalence at places higher up the stream.

These results emphasize still more strongly the opinion of the Board expressed in its letter of November last to the Newburyport Water Company, relative to the necessity of "obtaining a further supply of pure water without delay," and in the opinion of the Board such a supply cannot be obtained by developing the present spring-water sources.

The mayor of Newburyport applied to the State Board of Health, April 13, 1893, for advice as to taking the water of Artichoke River, in that city and the town of West Newbury, as a source of water supply for the city, such water to be purified either by artificial or natural filtration through sand. The Board replied as follows: —

BOSTON, April 24, 1893.

An examination of this source shows that by the construction of a storage reservoir as proposed it can be made to furnish a sufficient quantity of water for the city of Newburyport for a long time in the future. With regard to the quality of the water the examinations thus far made show it to be a water of fair quality, but it would not probably be satisfactory for drinking purposes without filtration. The Board is of opinion that it will be feasible to so filter this water that in connection with the existing works, or independent of them, an ample and satisfactory supply for the city can be obtained.

The Board makes a reply at this time instead of waiting for your further surveys and investigations because it understands that its advice is desired now in connection with pending legislation, and will advise you further with regard to the filtration of the water when the results of the further surveys and investigations are presented.

NORTH ANDOVER. The committee on water supply of the town of North Andover applied to the Board, Dec. 13, 1892, for advice relative to taking the water of Great Pond in that town for a public water supply. The Board replied to this application as follows: —

BOSTON, Jan. 16, 1892.

The State Board of Health has considered your application dated Dec. 14, 1892, with regard to a proposed water supply for the town of North Andover, to be taken from Great Pond within said town.

The Board has caused examinations of the pond and analyses of its water to be made, and finds that the water is of satisfactory quality for all the purposes of a public water supply and that the quantity of water which the pond will furnish is many times in excess of the quantity which will be required for the supply of the town.

The Board is therefore of opinion that Great Pond in North Andover is an appropriate source from which to take a water supply for the town.

PEABODY. The Water Board of the town of Peabody sent the following communication to the State Board of Health, April 18, 1893, relative to the threatened pollution of their water supply by drainage from new settlements upon the immediate watersheds of the two ponds used as water supplies: —

PEABODY, MASS., April 18, 1893.

State Board of Health, Boston, Mass.

GENTLEMEN: — By a vote of the water board, I am instructed to respectfully represent to you a matter of vital importance to the town of Peabody. Parties have purchased the land north of Spring and Brown's ponds, the water supply of the town, and have cut it up into house lots, and as the land on both places slopes toward the ponds, the matter of polluting the water in the ponds is deemed of such great importance to the town that the Water Board would respectfully request that a member of the State Board of Health come here some time to look over the premises, and suggest some remedy, if possible.

Yours respectfully,

HENRY BAETJE,

Clerk, Water Board.

In compliance with this request of the water board of Peabody, the secretary of the State Board visited the sources of water supply of the town, in company with the water board, and afterward addressed a letter to them, by instructions of the State Board of Health, giving such information as to existing statutes as would be serviceable for the protection of their water supplies from pollution.

ROCKPORT. An application was received from H. N. Woods and others, and the selectmen of Rockport, Jan. 4, 1893, asking the advice of the Board relative to the taking of a public water supply from Cape Pond, or Mill Pond Brook in that town, and in the event of these sources proving unsuitable, from the Gloucester Water Company. The Board replied as follows: —

BOSTON, Feb. 18, 1893.

An application with regard to Cape Pond as a source of water supply for Rockport was made to the Board on March 18, 1890, and the reply of the Board dated March 26, 1890, was as follows: —

The Board has caused samples of water to be taken from the pond and has had them submitted to chemical and microscopical examination. The water at the present time is not found by either examination to be of satisfactory quality. It contained an unusually large number of organisms, and is therefore specially liable to bad tastes and odors, such as have affected many water supplies in the State. It is also shown by analysis to contain a large amount of ammonia, which indicates the presence of decaying matter. It is not feasible to tell whether the water

at the present time is better or worse than at other seasons of the year; but, as a rule, the quality of the water of ponds is worse in the summer.

In view of this unsatisfactory condition of the water, the Board cannot at the present time advise that this pond will be a desirable source of supply for the town of Rockport, unless the water supplied is first efficiently filtered. If it should be found by subsequent examinations that the water of this pond is better at other seasons of the year than at the present time, the Board might have occasion to modify the advice above given.

Since the above date four samples of water were collected from the pond, in August and October, 1892, which showed by the chemical examination the presence of more organic matter than is desirable in water, and by the microscopical examination the presence of a large variety and number of organisms. On the whole, however, these samples indicated that the water was of better quality than in 1890. A sample collected in February, 1893, shows still less organic matter and fewer organisms, so that the water as represented by the last sample may be considered as of satisfactory quality for water supply purposes. Notwithstanding these changes for the better in the organic matters in the water, the mineral contents show that there is an increasing pollution of the pond by the waste matters which come from the glue factory upon the watershed, and there is little doubt that if these waste matters continue to affect the pond the water will be specially liable to bad tastes and odors caused by too great an amount of organic matter and too many organisms in the water, whereas if the waste matters were removed from the watershed so that they could not affect the pond by direct flow into it, or by filtration through the ground, the quality of the water would probably improve to a considerable extent in two or three years, and after a longer term of years the water in the pond would resume its natural character.

The Board is therefore of opinion that this pond should not be used for water supply purposes unless the pollution of its water ceases, but that if the pollution is stopped the water will become of satisfactory quality for the supply of the town.

With regard to the quantity of water which this pond will furnish, it will probably supply sufficient water for the present population of the town but not enough to provide for a growth of population, and in designing works for taking a supply it would be well to take into account the need of an additional supply, which can probably be obtained from the streams which come from a northerly direction into the brook which flows from Cape Pond, or possibly from wells in the low land through which this brook flows.

Millpond Brook, so-called, is naturally inferior to Cape Pond as a source of water supply for Rockport, and it is very doubtful if it could be made to furnish a sufficient quantity of water for even the present population.

SALEM. The water commissioners of Salem applied to the State Board of Health, Feb. 17, 1893, for advice relative to increasing the present water supply of the city by taking water from Beaver and Norwood's ponds and Longham Meadow, certain regions which are tributary to Miles River, and conveying the same by a canal to Wenham Lake, the present source of supply. The Board replied as follows: —

BOSTON, April 4, 1893.

Investigations of the present source of water supply for Salem and Beverly (Wenham Lake) show that the safe capacity of this source has been exceeded to a considerable extent, and that a new supply should be provided by the end of 1893 if not before. The most economical source from which to obtain such a supply is that referred to in the application, as these brooks, at the point where their waters can be diverted, are only about half a mile from Wenham Lake, and so few feet below its level that the water can be diverted into the lake without pumping by raising the water of the brooks by means of a low dam.

Since your application was made two sets of analyses of water from these brooks have been made. The first one was made on March 1st, when there was a large amount of snow on the ground and very little water running in the streams. At this time the water was very dark-colored and had a disagreeable odor and taste, so that it would be wholly unsatisfactory as a source of water supply if taken directly into the pipes. The next sample was taken on March 15th when a large part of the snow had melted and a great amount of water was flowing in the streams. The water of the Longham Meadow Brook at this time, although somewhat turbid, owing to the presence of earthy matter, had only one-third as much color as on March 1st and was in other respects a much better water. The water of the brook flowing from Norwood's Pond also showed a very decided improvement, but not as much as in the other case, as the water from the melting snow had not had time to crowd out all the water previously in the ponds on this stream.

If the water of these streams was turned into Wenham Lake near its outlet, as is now proposed, it would mingle with the water

of the lake, making a mixture very much better than the water coming from the brooks, and, in addition, the water standing for so long a time before being used as it would in so large a body of water as Wenham Lake would improve to a very considerable extent by bleaching and sedimentation. In order, however, to maintain as nearly as possible the present standard of Wenham Lake water, it is highly desirable that only so much water as may be necessary should be turned into the lake from these brooks, and that it should be turned in at the season of the year when the water in the brooks is in its best condition.

The stream at the proposed point of diversion is as before indicated lower than the lake; and, in order to divert the water into the lake by gravity, it is necessary to raise the water in the stream by means of a dam. The question has therefore been raised as to whether it is not best to make a dam high enough to form a large reservoir which will furnish a valuable addition to the present storage capacity. The surveys of this reservoir have not yet been completed and it is not feasible to tell from observation alone what its character will be. It seems probable, however, that unless a very large amount of money is spent in its preparation the water would deteriorate to a very considerable extent by standing in it and that, at the present time, it would be better to construct a dam having only sufficient height to turn the water into the lake. Even a low dam at this place will flow the water back for a long distance up the valley of the Longham Meadow Brook, and if the reservoir is to be kept filled at all seasons of the year it should be prepared to receive this water by the removal of all soil and vegetable matter and the deepening or filling of the shallower portions. If, however, the reservoir should be filled to divert water into the lake only in the winter and spring it is not improbable that satisfactory results may be obtained by a less expensive preparation.

It may be feasible by ditching or otherwise draining the swampy lands or ponds upon the watersheds of these brooks to greatly improve the quality of the water flowing in them, and the Board would advise that this question of the improvement of these sources should be investigated and that any act authorizing the taking of these sources should contain such provisions as will permit this work to be done.

The total area drained by these streams is much larger than that now supplying Wenham Lake, and, in connection with Wenham Lake and its watershed, should furnish a supply of water for Salem and Beverly for a long time in the future without building a large storage reservoir, provided the water is economically used.

The amount of water now consumed by Salem and Beverly, as given in the annual reports of the water boards, is unusually large for such communities, and the Board would therefore advise that measures should be taken to restrict the waste of water; not, however, with the expectation that the need of an additional supply can be avoided, but rather with a view to maintaining as nearly as possible the present standard of quality of the water supply by adding to it as little water from the new sources as possible, and also with a view to making the proposed addition provide for as far in the future as possible.

Taking everything into consideration the Board is of opinion that the two streams mentioned in your application, including with them a small portion of the main stream below their confluence, are the most appropriate sources for obtaining an additional water supply for Salem and Beverly.

The Board has given its present views in a general way as to the best method of obtaining such a supply from these sources, but will advise you more in detail when you have made a further study of the subject and can present more definite plans.

SAUNDERSVILLE. The treasurer of the Saunders Cotton Mills in Grafton, applied to the Board, October 18, for advice as to supplying the mill and houses in its neighborhood with water from springs upon a hill near the village. The Board replied as follows: —

BOSTON, Nov. 2, 1893.

The Board has caused an analysis of the water from one of these springs, and an examination of the territory from which they derive their supply, to be made. The water is very soft and of suitable quality for all the purposes of a water supply, and the covering which you propose to put on the reservoir will tend to preserve the good quality of the water when it is stored. In order to maintain the purity of the spring water, care should be taken to exclude all surface water.

Judging from the quantity of water discharging from the springs at the time the examination was made by the engineer of the Board, and from statements made to him as to the permanence of these springs, it seems probable that they will furnish enough water to make them a valuable source of supply for the mill and the houses in its vicinity.

In addition to the sample of water from the spring, another sample, taken from a well which now supplies water to the mill, was analyzed. This analysis shows that a portion of the water

coming to this well has at some time been polluted and afterwards thoroughly purified by its passage through the ground to the well. While there is no reason to think that this water, in its present condition, would be injurious to the health of those drinking it, it is a much less desirable source of domestic supply than the springs on the hill.

SCITUATE. M. R. Simmons and others, and the selectmen of Scituate applied to the Board, Dec. 10, 1892, for its advice relative to taking water for supplying the village of Scituate Harbor, from the valley of Satuit Brook in that village. The Board replied as follows: —

BOSTON, Feb. 21, 1893.

The general outlook for obtaining a sufficient quantity of water for present and future requirements from the ground where the test wells are located is favorable both as regards the area and topography of the watershed from which the supply would come, and because the test wells show the presence of a layer of porous sand from which water can be drawn. The amount of water to be obtained, however, will depend upon the extent of this porous layer, and the freedom with which water can be pumped from it, and it will be advisable to make some further tests to determine these features before constructing works.

The sample of water collected from a flowing test well is of good quality, and it seems probable that the quality of the water will remain good when a supply is pumped from the ground. In some cases, however, the quality of water from wells in a meadow deteriorates when pumped, and it would be well to have additional samples analyzed when a pumping test is made.

SHARON. The board of health of Sharon, under instructions from the town, requested the advice of the State Board of Health, Aug. 28, 1893, with reference to the possible pollution of the public water supply of the town, under existing conditions, and as to the best practicable method of assuring its purity in the future. The Board replied as follows: —

BOSTON, Oct. 6, 1893.

When any part of the territory from which a well derives its supply is populated and the waste waters of this population are discharged into the ground, these waters percolate downwards until they reach the level of the water in the ground, and then, mingling with the natural ground water, filter slowly toward the well. In

such a case the dissolved mineral matters (for instance, common salt, and the salts of lime and magnesia which make water hard) are not removed by the filtration; but the organic matters may be decomposed and wholly transformed into harmless mineral matters by filtering through the ground for a sufficient distance.

The State Board of Health has caused chemical analyses of water from the well of the Sharon Water Company to be made from time to time since June, 1887, the last analysis being made in September, 1893. These analyses show the presence in the water of some of the mineral matters due to the population upon the territory from which water filters toward the well, and the water, although not hard, is harder than it would be if it were not for the population upon this territory. They also show that such polluted waters as have mingled with the ground water have been very thoroughly purified at all times, and the recent analysis fails to reveal even a trace of organic matter. It may therefore be said that the water is very pure at the present time.

There is scarcely a doubt that the waste waters discharged into the ground from the more distant points will continue to be thoroughly purified before reaching the well, and the effect of an increase in population at these points would be to increase the hardness of the water rather than to render it injurious to health. There is a greater probability that the water may at some time be polluted by the wastes which enter the ground at nearer points, say within a distance of from 600 to 800 feet from the well; and it is highly desirable that within this distance this method of disposing of the waste matters shall cease.

If there should be a very large increase of population upon the more distant territory which contributes water to the well, it may be necessary at some time in the future to provide a water-tight system of sewers to carry off the liquid wastes, or to obtain the water supply from some new location.

SOUTHBRIDGE. The Southbridge Water Supply Company applied to the Board for its advice, Sept. 5, 1893, relative to the question of increasing the public water supply by building a new dam about one mile south of the present upper reservoir, and as to the improvement of the present supply and storage capacity. The Board replied as follows: —

BOSTON, Oct. 13, 1893.

We are informed by your engineer that this new reservoir will have sufficient capacity to store 50,000,000 gallons; but, as you

have not made surveys of the watershed, to determine its area, it is not feasible to advise you other than in a general way as to the quantity of water which this source will furnish.

It is also the case that when this source was inspected by an engineer of the Board, there was no water running in the stream at the site of the proposed dam, so that it was not possible to get a sample of water for analysis. The inspection of the watershed by this engineer, however, indicated that the water flowing from it was naturally of good quality, and that more water could probably be obtained from this source than from the present works.

The water would probably deteriorate somewhat by storage in this large reservoir, in any case; but much more if the reservoir is not cleaned, than if it is thoroughly cleaned by the removal of all soil and vegetable matter.

In answer to your second question asking the advice of the Board with regard to the improvement of the present supply, it may be said that it does not appear feasible to increase the storage in a satisfactory manner nor to materially increase the quantity in any other way. It should also be borne in mind that if you adopt the new source and construct the large proposed reservoir upon it, it will be feasible to operate the two systems together so as to utilize some of the water which now flows to waste over the lower dam of your present works in the spring of the year. For example, when enough additional water takers have been connected with the works to use all of the water which the present and proposed works will furnish in a dry time, it may frequently happen that the lower reservoir will be overflowing, while the proposed reservoir, owing to its large size, will not be full. At such times it will be feasible to supply the greater part of the town from the old source, thereby permitting less of the water to flow to waste, and reserving the water of the proposed reservoir for use during the drier portions of the year.

With regard to the improvement of the quality of the present supply, the measures suggested are the removal of any organic matter which may be in the reservoir, and the ditching of any lands of a swampy nature over or through which the streams flow to the reservoirs, so as to prevent, as far as possible, the water from coming into contact with organic matter or standing upon the surface of these lands.

It is improbable that your present and proposed works together will furnish as much water as ought to be provided for a large and growing town like Southbridge, and the Board would therefore advise that you have thorough investigations made with a view to determining the best source for the permanent supply of the town.

Should you find a source which will furnish an adequate supply of good water it would probably be a measure of true economy to adopt it at once, rather than to spend money upon a source which in a very few years is likely to prove inadequate, if the pipe system of the town should be extended to any considerable extent. Should your investigations of the larger sources lead you to conclude that it is desirable to adopt one of them, the Board will advise you further in this matter when you shall have submitted the results of your investigations.

The Southbridge Water Supply Company submitted a second application, Oct. 14, 1893, stating that they had made the investigations of the larger sources of supply suggested by the Board, to which the Board replied as follows: —

BOSTON, Dec. 8, 1893.

The State Board of Health received from you on Oct. 16, 1893, a second application with regard to increasing the water supply of the town of Southbridge, and at a subsequent date received a plan of a storage reservoir which it is proposed to build on Hatchet Brook.

The Board has caused an examination of the premises by one of its engineers, and analyses of the water from Hatchet Brook at the site of the proposed dam, from one of its principal tributaries and from Hatchet Pond to be made. The examination and analyses showed the water to be free from pollution, and that it is soft and of suitable quality for all the purposes of a public water supply. In order to maintain the purity of the water when it is stored, the reservoir should be prepared for use by the removal of all soil and vegetable matter from its bottom and sides.

With regard to the quantity of water, this source with a storage reservoir constructed in accordance with the plan submitted should furnish in the driest year a sufficient quantity of water for a population considerably in excess of the present population of Southbridge, and it is capable of still further development.

The Board therefore concludes that Hatchet Brook at the proposed point of taking is a suitable source of water supply for the town of Southbridge.

SOUTH DEERFIELD. The South Deerfield Water Company applied to the Board, Nov. 17, 1893, for its advice as to the propriety of taking Clapp's Trout Brook as a water supply for South Deerfield. The Board replied as follows: —

BOSTON, Dec. 14, 1893.

Clapp's Trout Brook is a small stream which flows down the easterly slope of the range of hills situated about two miles west of the village of South Deerfield. North and south from this brook there are two much larger streams which flow from the same range of hills, namely, Roaring Brook, in the town of Whately, and Mill River, of which Clapp's Trout Brook is a branch, in the town of Conway. Examinations of all of these sources, by an engineer of the Board, and analyses of the water have been made. The analyses show in all cases a water of excellent quality, slightly harder than most of the drinking waters of the State, but yet not hard enough to be objectionable on this account. There was little difference in the hardness of the samples from Clapp's Trout Brook and Roaring Brook, though the latter had a slight advantage in this respect. The sample of water from Mill River was considerably harder than either of the others.

The quantity of water which Clapp's Trout Brook will furnish in a very dry year cannot be accurately estimated from the information now in the possession of the Board. It is obvious, however, from an examination of the territory and of the State map, that the area drained by the brook is quite small, and it is doubtful if this source will furnish enough water in a dry year to supply the village of South Deerfield, after the water has been generally introduced.

Roaring Brook will certainly furnish all the water required, and Mill River, above the point where its water can be diverted to the village by gravity, will probably furnish a sufficient quantity of water. The latter source has the objection, however, that it is much further from the village.

With its present information the Board does not advise the adoption of Clapp's Trout Brook as a source of supply for the village; but it might modify its views if surveys should show that the watershed has a larger area than is now supposed, or should show that it is feasible to build a reservoir or reservoirs upon it, in which to store a sufficient amount of water to tide over dry periods. There seems to be no doubt that a satisfactory supply of water can be obtained from Roaring Brook.

The Board advises you to have further investigations made to determine whether Clapp's Trout Brook will furnish a sufficient supply of water, and, if it will not, to determine whether it is not feasible to obtain a supply from Roaring Brook. When you have further information to present the Board will advise you further in this matter.

STOUGHTON. The water commissioners of Stoughton sent a communication to the Board, Sept. 7, 1893, stating that works recently completed for supplying water to the town had proved wholly inadequate, and that the commissioners desired the advice of the Board relative to taking some new source or devising some method of obtaining a larger supply from the present plant. The Board replied as follows: —

BOSTON, Oct. 13, 1893.

In April of last year the Board received from you an application for its advice with regard to a new water supply for the town of Stoughton, in which you designated the region near Knowles Brook and Muddy Pond for the consideration of the Board. In the reply to this application, dated May 5, 1892, the Board, in giving the relative capacities of the two sources mentioned, estimated that the Muddy Pond source would furnish a supply for nearly if not quite double the present population of Stoughton, but qualified the statement by saying that "these estimates are based upon the assumption that loose gravelly ground can be found in both of these locations to a depth of from thirty to forty feet, and may require modification if examinations of the ground, which should be made before any final decision is reached, show that this is not the case." The reply concluded with the following statement: — "The Board is therefore of the opinion that the most appropriate source from which to obtain a water supply for Stoughton is the ground in the vicinity of Muddy Pond, provided further examinations show that porous material at this place is of sufficient depth and extent."

The new well has been located one-quarter of a mile or more below Muddy Pond, and, owing to its location, the slight depth to which the water in it can be drawn down with the present arrangements for taking water, and probably, also, to the somewhat impervious nature of the material in which the well was sunk, the quantity of water which it will supply is small. Under the present conditions it is obviously desirable to bring additional water to the works already constructed, if it can be done at a reasonable cost, rather than to make any radical changes in the works.

Near the upper end of Muddy Pond, as you well know, there are many large springs outcropping at the base of the high land which partially surrounds the pond. There is no reason to doubt that this spring water, as it comes from the ground, is of excellent quality; and if a sufficient quantity of such water can be turned into the present pump well it would furnish a most excellent water supply for the town.

The outflow from Muddy Pond represents quite correctly the total volume of water furnished by the springs above referred to, and by such other springs as may be located in the bottom of the pond or in the swamp surrounding it. A measurement of the outflow from the pond made on April 26, 1892, showed the volume to be 1,410,000 gallons per twenty-four hours, and another measurement made on Sept. 11, 1893, showed that the flow was then fully 1,000,000 gallons per twenty-four hours. The comparatively small difference between the measurement made in the spring of the year, when the flow would naturally be greatest, and in the autumn, when the flow would naturally be low, shows that the yield of these springs is remarkably constant.

The smaller quantity of water is about four times as large as the average daily quantity required to supply the present population of Stoughton. It would not be fair, however, to reckon that this source would supply four times the present population of Stoughton, because, during dryer seasons, the springs are likely to be lower than at the present time; and provision is also to be made for the maximum rate of consumption in summer, rather than the average rate throughout the year. There now appears to be an abundant supply of spring water for a much larger population than that of Stoughton entering the pond from the springs, which can be conveyed by an intercepting pipe to the present works. The Board would therefore advise that provision should be made for intercepting the spring water which now finds its way into the pond before the water has been exposed to the light or come in contact with the vegetable matter in the swamp surrounding the pond, and for conveying the intercepted water to the present works.

While the main feature of works for carrying out the advice above given is a pipe tapping the springs and extending from them to the present works, there are many precautions which should be taken to insure success. The attempt should be made to collect *all* of the spring water which enters the pond, and for this reason the intercepting pipe should be everywhere at a lower level than the water in the pond. In order to intercept the water of the springs, the pipe through that portion of its length where the springs are located should be laid with open joints and surrounded and covered with a liberal amount of screened gravel. Smaller branch pipes may also be required at those points where the spring water outcrops in the greatest quantity.

The pipe laid from the territory where the water would be collected to the present works should be of large size, say eighteen inches in diameter, so that it will convey the water to the vicinity of

the present collecting well with very little loss of pressure due to friction; and this pipe should communicate with the 12-inch pipe leading from the collecting well to the pump well. The 12-inch pipe should have a check valve on it above the point where the new pipe connects with it to prevent the water from backing up into the collecting well and being lost by leakage into the ground about this well. It will also be necessary to make the joints of the new pipe water-tight wherever the pressure of the water in this pipe will cause it to leak out through the joints.

In order to concentrate the flow of the whole twenty-four hours so that it can be pumped in the daytime it will be necessary to stop the flow of water from the pipe at night and permit it to back up in the gravel surrounding and in the vicinity of the open-jointed pipe.

The Board would urge upon you the advisability of having this new work done in a liberal and thorough manner so as to insure the collection of all of the spring water without deterioration of quality. The total cost of doing this work thoroughly would be but a very small percentage of the whole cost of the system of water supply for the town, and yet it represents the most important part of the whole work, namely the collection of an ample supply of excellent water.

UXBRIDGE. The committee on additional water supply for the town of Uxbridge applied to the Board, March 18, 1893, for its advice as to the comparative merits of Seagrave Brook and Cold Spring Brook in Uxbridge, and of Mendon Pond in Mendon, as sources of water supply for Uxbridge. The Board replied as follows: —

BOSTON, April 4, 1893.

The Seagrave Brook drains so small a territory that, even if extensive storage reservoirs should be constructed upon it, it would not probably furnish a sufficient supply for even the present population of Uxbridge after water was generally introduced in all of the villages; and this source has no advantage in regard either to the quality of the water or to economy of construction which should lead to its introduction as a temporary source of supply.

Cold Spring Brook, at the proposed point of taking at the old sawmill site, below the Douglas Road, drains so large a territory that its natural flow, supplemented by a comparatively small amount of storage to tide over the dryer portions of the year, would be sufficient to supply Uxbridge with water for many years; and should the supply at any time prove insufficient, the capacity

of the source may be increased by providing additional storage capacity. A sample of water was collected from the brook near the proposed point of taking on March 25, 1893, which showed the water to be a fairly satisfactory one for water supply purposes. The sample was collected, however, at a time when the streams were swollen by the water from melting snow, and the analysis may, therefore, differ considerably from the analysis of the water at other seasons of the year.

The principal objection to this source is its low level, which makes it necessary to pump the water and consequently increases both the first cost of the works and the annual cost of maintenance. When compared with Mendon Pond it seems probable that the first cost of works from Cold Spring Brook will be as large on account of the cost of a pumping station, offsetting the additional length of pipe required to take water from Mendon Pond; and Cold Spring Brook has the disadvantage of the continued expense of maintaining a pumping station, while the water will flow from Mendon Pond by gravity.

It was not feasible at the time this examination was made to obtain a representative sample of water from Mendon Pond, as the ice was not strong enough to bear the weight of a person, and the water near the edges was affected by the water entering the pond from the melting snow.

To sum up the comparative merits of the different sources, the Board is of opinion that the Seagrave Brook source has no advantage either in regard to quantity, quality or cost. A final opinion in regard to the relative merits of Cold Spring Brook and Mendon Pond in regard to the quality of the water cannot be given at the present time on account of the fact that the few examinations made may not be representative of the quality of the water at all seasons of the year, but it seems probable that Mendon Pond can be made to furnish the better water. The cost of a water supply from Mendon Pond will be very much less than from Cold Spring Brook when the cost of maintaining a pumping station is taken into account.

WAKEFIELD. The Wakefield Water Company requested the advice of the Board, Feb. 23, 1893, relative to introducing "an additional water supply" for Wakefield and Stoneham, from "filtering galleries, wells, or basins upon the banks of that portion of the Saugus River lying within the limits of the town of Wakefield, and above the milldam near the Montrose station of the Salem branch of the Boston & Maine Railroad." The Board replied as follows: —

BOSTON, April 14, 1893.

From such data as are now available the Board believes that the capacity of the present source (Crystal Lake) in a series of dry years has been practically reached, so that there is need of an additional water supply for these towns. It has already expressed and still holds the opinion that the water of Quannapowitt Lake, one of the sources named in your original act of incorporation, is now unfit for the purposes of a domestic water supply. This opinion as to the quality of Quannapowitt Lake water applies to taking water directly from the lake, but if the water was taken after it had been thoroughly purified by filtering for a long distance through the ground or by any other thorough method of filtration it might be used. It seems probable, however, that the most satisfactory additional supply for the towns of Wakefield and Stoneham can be obtained by taking water from the ground at some point above the dam at Montrose, as indicated in your application.

In the absence of any investigations to determine either the quality or quantity of water which may be obtained from different portions of this territory, it is not feasible to give any specific advice in these respects at the present time.

The city of Lynn, which now takes its supply from sources within the Saugus valley, is in urgent need of an additional supply of water and desires to take it from this valley, and the valley is also nearer other communities in need of additional water supplies than any other large sources not now in use or so much polluted as to be unfit for water supply purposes. While, therefore, the Board believes that the towns of Wakefield and Stoneham should have the first right to a water supply from the portion of the valley within the limits of the town of Wakefield it does not believe that they should control more territory than is necessary for this purpose.

In view of the impracticability of making any fair apportionment of territory at the present time, the Board in its reply to the application of the city of Lynn relative to an additional water supply, concluded that Lynn should be granted the right to take water from any portion of the valley of the Saugus River not already granted by the Legislature to some other town or water company, but that this grant should be subject to the restriction that the towns of Wakefield or Stoneham, or the company supplying them with water, may be authorized to take water from this valley at any point within the limits of the town of Wakefield, and to the extent required to furnish in connection with Crystal Lake, the present source of supply, a supply of water for these towns; provisions to be made in connection with any grant of this character, however, that whenever these towns, or the company supplying

them with water, should take a supply from any source in the Saugus valley other than those already controlled by the Wakefield Water Company they should be required to pay to the city of Lynn a fair proportion of the amount already paid by said city for water or land damages, and if they should utilize to any extent works previously constructed by the city they should pay a fair proportion of the cost of these works.

The Board advises your company to make investigations with reference to obtaining a further supply of water from the ground in the Saugus valley, in the territory referred to in your application, and will advise you further when the results of such investigations are presented. The greatest care should be exercised to prevent the pollution of your present source of supply by the increasing population on its watershed.

WALPOLE. The committee on water supply of Walpole applied to the State Board of Health March 9, 1893, for its advice relative to a public water supply for the town, to be taken from the ground in the valleys of Mill Brook and Traphole Brook in East Walpole, tributaries of the Neponset River. The Board replied as follows: —

BOSTON, April 10, 1893.

In accordance with your request for an early reply to your application relative to a water supply for the town of Walpole, the State Board of Health has caused a preliminary examination to be made, and finds that the local conditions favor the plan of taking a supply from the ground within the limits of the town, as suggested in your application to the Board. As it is stated in your application that the different sources within the town are to be fully investigated, the Board will make a further reply regarding the merits of these sources after the results of the investigations have been received.

After considering the needs and interests of other towns in the vicinity of Walpole the Board finds no reason to doubt that Walpole should at the present time have the right to any source within its limits. There is one source, however, viz., Traphole Brook, in the easterly part of Walpole, which subsequently flows through the southerly corner of Norwood and then forms the northerly boundary of the town of Sharon, which may in the future be of value to some other community as a source of additional water supply; and if it should be found that this source is not the best one for Walpole and works should be built to take a supply from another source, the Board is of opinion that any rights which are now

granted Walpole to take a supply from this source should cease. This could be accomplished by including in an act giving Walpole the right to take water from any source within its limits a provision that the right of the town of Walpole to take water from Trap-hole Brook shall become void when the town shall have selected some other source of water supply and introduced water therefrom.

The results of the investigations referred to in the foregoing letter of advice having been submitted, the Board made a further reply as follows: —

BOSTON, June 5, 1893.

The investigations made near the Neponset River, not very far above the Blackburn water privilege and just below Low Brook, showed very satisfactory results as regards the porosity of the material, the freedom with which water could be pumped from the test wells and the quality of the water. Taking these results in connection with an examination of the surrounding territory and the size of the streams, the Board finds no reason to doubt that an ample supply of excellent water can be obtained from a well or wells located in the porous material in this vicinity.

WALTHAM. The water commissioners of Waltham applied to the State Board of Health July 31, 1893, asking for a re-examination of their sources of water supply, and for the advice of the Board as to the measures requisite to improve the quality of the water supplied to the city, and to prevent the recurrence of the offensive tastes and odors which were liable to affect it. The Board replied as follows: —

BOSTON, Dec. 22, 1893.

An examination of your collecting well and distributing reservoir was made promptly by one of the engineers of the Board, and samples of water were taken for analysis, which showed that the conditions were on the whole substantially the same as they were on Oct. 3, 1892, when the Board replied to a similar application made by you, and advised protecting the water from the light both at the well and at the distributing reservoir. The results of these analyses were sent you; and, as you then decided to proceed at once with the covering of the well, it was thought best to defer making the formal reply until it was feasible to include in it the results of further investigations, to ascertain the character of the water entering the well at different points and the effect of covering the well.

An examination was made to ascertain the temperature of the water entering the well at the bottom, at different points around its circumference, and it was found from thirteen observations, made on Sept. 9, 1893, that the average temperature of the water entering the well was 55.7 degrees, while at the same time the temperature of the river water was 68 degrees. These results indicated that no large proportion of the water filtered from the river by any very direct course, but there was a slight difference (3.4 degrees) in the temperature of the water at different points, which indicated that there might be a difference in the source and quality of the water entering different parts of the well. An attempt was therefore made to obtain samples of water entering the well at different points at the bottom, before it had mingled with the water already in the well, but it was not found feasible to do this.

Since the well has been covered two samples of water have been received from it, one collected November 14, and the other Dec. 12, 1893. These samples are entirely free from the microscopical organisms which were always found in the well before it was covered, and are clear, colorless and free from odor.

It is now feasible for the first time to ascertain the true chemical character of the water which enters the well, because, before it was covered, its character changed so rapidly, owing to the vegetable growths in the water, as to materially affect the results. There is nothing in the present analysis of the water to indicate that it is at the present time other than an excellent water for the purposes of a public water supply. The free ammonia, however, is somewhat higher than it would be in a water which had received the highest degree of purification by filtering through the ground, and it will be of interest to observe subsequent analyses of the water to see whether this constituent increases or diminishes.

With regard to the samples from the distributing reservoir it may be said that they show that the water in the reservoir is in substantially the same condition as in the past, and that it contains an abundant growth of the minute vegetable forms which give the water an unpleasant taste and odor.

The Board would therefore repeat its advice of last year, that by covering your present reservoir or building a new covered reservoir, as may be found best, you provide for conveying the water from the source to the water consumers without permitting it to be exposed to the light at any place.

WEBSTER. The water commissioners of Webster applied to the Board, June 23, 1893, for its advice relative to taking

a supply of water from the ground near Lake Chaubunagungamaug. The Board replied as follows: —

BOSTON, Oct. 6, 1893.

The State Board of Health has considered your application with regard to a proposed water supply for the town, to be taken from a well located near Lake Chaubunagungamaug, and has caused an analysis of a sample of water from a test well at the site of the proposed well to be made, also an examination of the surrounding territory. The analysis shows that the water is very pure and soft.

The sample probably represented water which was percolating through the ground toward the pond; while if a large quantity of water should be pumped from the ground at this place, it is probable that a part of it would be derived by filtration from the lake. Judging from the experience at other places in the State, the water obtained in this way from the lake would be so thoroughly changed in its character by filtration that it would not differ to any noticeable extent from the water coming to the well from the land side.

Both the examination of the ground at the site of the well, made under your direction, and a general examination of the surrounding territory, indicate that a large quantity of water can be collected from the ground at this place; and if the supply should prove insufficient, a supplementary supply of very good surface water can be obtained from the lake. It is desirable, however, that a full supply should be obtained from the ground, on account of the better quality of the water from this source.

WESTBOROUGH. The water commissioners of Westborough applied to the Board for advice, Sept. 26, 1892, relative to the improvement and increase of the public water supply, submitting at the same time a description of a proposed plan. The chief engineer of the Board visited the town, and made such suggestions as seemed necessary for the modification and improvement of the plan, and a new plan was submitted to the Board, Jan. 19, 1893. The Board replied as follows: —

BOSTON, Feb. 13, 1893.

Your water supply is now derived from two reservoirs, the upper one a storage reservoir of considerable size and the lower one a smaller basin which derives its supply from the upper one by the filtration of the water through the intervening porous ground. You find that the quality of this filtered water is very much better

than that of the water in the upper reservoir, but that at times the quantity is not sufficient to supply all of the water needed, and you therefore have to draw some of the water directly from the upper reservoir; moreover, the upper reservoir sometimes overflows into the lower one, injuriously affecting the quality of the water in it.

What is now desired, therefore, is a means of increasing the supply of filtered water during portions of the year and a means of diverting the overflow of the upper reservoir from the lower one.

The plan now submitted shows a contemplated channel for diverting the waste water from the upper reservoir past the lower one, and with the accompanying communication explains the result of certain tests which have been made with reference to the present conditions under which water is now filtering from one reservoir to the other, and of other tests made to determine the means by which the filtration may be facilitated.

Judging from the experiments which you have made, it seems quite certain that a material increase in the amount of filtered water can be obtained at a moderate expense by digging a ditch with sloping sides down into the sand and gravel at the shore of the upper reservoir between the dam and the waste way, this ditch to be separated from the water in the reservoir by an embankment extending above high water mark. This ditch should also be divided into sections, each of which should communicate with the reservoir by means of a pipe provided with a gate by which the water can be shut off during those portions of the year when enough water naturally filters through the ground, or when it becomes necessary to clean any section of the ditch so as to expose a fresh sand surface. The pipe and bottom of the ditch should either be placed at the lowest practicable level in the beginning, so that the system will operate when the upper reservoir is drawn down several feet, or they may be placed at a higher level in the beginning and subsequently lowered when the water recedes.

The experiments show that a ditch of this kind would let the water into the ground much more freely than it now gets in through the nearly impervious material at the bottom of the reservoir.

On the opposite or north side of the waste way a similar construction could be used to facilitate the filtration of water, but the ditch should be placed far enough back from the edge of the reservoir so that it will be wholly in clean sand or gravel below the surface of the water in the reservoir.

The contemplated filtering drain, intended to collect water from the ground and discharge it into the lower basin, if placed with its bottom nearly at the level of low water in the lower basin, would

undoubtedly increase to a considerable extent the quantity of filtered water. To avoid the danger of imperfect filtration, however, it would be desirable to limit its length to 150 feet from the shore of the lower basin rather than to make it 235 feet long, as shown upon the plan. This drain should connect with the lower basin by a pipe provided with a gate so that it can be shut off during those portions of the year when enough water naturally filters through the ground, and thus avoid an unnecessary draft upon the upper reservoir.

The new channel to divert the overflow from the upper reservoir past the lower basin is a very desirable feature, and if by removing the soil and fine material this channel can be prepared so that all the material beneath it will be sand or gravel it may also be feasible to use it as a supplementary filtration area in cases of emergency. In order to do this it would be necessary to lay a pipe to bring water from the upper reservoir to the channel, and to erect temporarily a low dam near its lower end.

WEST SPRINGFIELD. The water commissioners of West Springfield applied to the State Board of Health May 1, 1893, for its advice relative to taking an additional water supply from certain specified sources in that town and in Agawam. The Board replied as follows: —

BOSTON, June 1, 1893.

The State Board of Health has considered your application with regard to a proposed additional water supply for your town, including the village of Mittineague, which is at too high a level to be supplied from the present source. You have called the attention of the Board to the Craig Spring and Silver Stream, which can be utilized to supply the village of Mittineague by pumping, to the Leonard Brook in Agawam, which can be used to supply a portion of the lower village by gravity, to the Lathrop Spring and Hyde Brook, which can be diverted into the present reservoir, and to a more distant source, viz., a spring and brook at the Bear Hole, so-called, in the north-westerly part of the town, from which water would have to be supplied by pumping.

All of these sources have been visited by the engineer of the Board, and from all except Silver Stream samples of water have been collected and analyzed, and copies of the analyses are transmitted herewith, together with the average analysis of water from the present storage reservoir for the year ending in May, 1888.

The Craig Spring will furnish a soft water, and one of very good quality, provided it is collected by means of pipes leading to a

well, or by other suitable works, without exposure to the light, and when pumped is stored in a reservoir which is also covered to exclude the light. Care would also have to be taken to prevent any contamination by surface water running down the ravine in which the spring is situated.

The water of the Leonard Brook is soft and of very good quality.

The sample of water from the Lathrop Spring was necessarily collected after the water had passed through a rank growth of vegetable matter, which may have affected the analysis to some extent. This water is harder than the other waters examined. There seems no reason to doubt, however, that if taken directly from the ground and diverted into the present reservoir it would not change the character of the water in the reservoir enough to be objectionable.

The sample from Hyde Brook had a moderate color, indicating that this water is affected to some extent by contact with vegetable matter in swampy places. At the time the sample was collected, the water, though not as desirable as the spring waters, would be classed as a fairly good water for all purposes, but it is not feasible to tell from a single examination in the spring of the year what the character of this water would be in summer.

The water of the spring at the Bear Hole is of excellent quality, though its hardness is about twice that of the present water supply. The degree of hardness, however, is not great enough to make the water objectionable for water supply purposes. Bear Hole Brook, at the time the sample was collected, was receiving the overflow from Ashley Pond, and the quantity of water was unusually large. Under these circumstances the analysis would have but little value as an indication of the average quality of the water. The water had less color than Hyde Brook, but contained rather more organic matter. The degree of hardness was nearly the same as that of the water from the spring near it.

The plan proposed by you, of establishing a pumping station at the Craig Spring and supplementing the present supply to the lower village by introducing water from Leonard Brook, and connecting the Lathrop Spring with the present reservoir, has the merit that it will add to the present supply a considerable quantity of very good water by a comparatively small expenditure, and it may be wise to carry out this plan. The Board does not, however, have sufficient information as to the capacity of the present source in very dry years, or as to the amount which the supplementary sources will furnish in such years, or can be made to furnish by the construction of additional storage reservoirs, to enable it to advise definitely as to whether it is better to carry out this plan to

make the Craig Spring and the present reservoir the main source of supply, to be supplemented by such other sources in the vicinity as will supply the lower village by gravity, or whether it is better to go at once to a greater distance to obtain a supplementary supply from a source which will furnish a larger quantity of water. In order to obtain such information it would be necessary for you to employ an engineer skilled in the design and construction of water works to make a more complete study of this question, and the Board advises that this be done.

WHITMAN. The committee on water supply of the town of Whitman applied to the Board, April 12, 1893, for its advice relative to a public water supply from certain specified sources in that town and the towns of Hanson and Pembroke. The Board replied as follows: —

BOSTON, May 4, 1893.

In this application you make special mention of Maquam, Oldham and Big Sandy Bottom Ponds and Silver Lake. The Board has caused examinations to be made of these and other ponds in the vicinity. Complete chemical and microscopical examinations have been made of samples of water from Maquam, Oldham, Furnace and Big Sandy Bottom Ponds and Silver Lake, and less complete examinations of samples from Indian Head Pond and Factory Pond in the town of Hanson and Stetson's Pond in the town of Pembroke. Copies of these analyses are transmitted herewith.

The water of Indian Head and Factory ponds has a very dark color, and in other respects these ponds are less desirable than some of the others, so that they may be discarded from the list of desirable sources. Stetson's Pond presents no advantages either as to the quality or quantity of water as compared with Oldham Pond, and on account of its greater distance is a less available source for Whitman.

The water of Maquam Pond is practically colorless and in most other respects is a very satisfactory pond water. It had, however, at the time of the examination slightly more odor after standing in a bottle, and contained a greater number of microscopical organisms than any other sample of which a complete examination was made. All surface waters contain a greater or less number of these minute organisms, which are the cause of the odors noticed, and both the numbers and the amount of odor are liable to vary from time to time, so that too much significance should not be attached to the comparisons of only a single series of analyses. It is not feasible to tell from the information at present available whether or not Maquam Pond will furnish sufficient water to meet the requirements of the town of Whitman even in the near future, and this

source should not, therefore, be adopted in any case without making provision for supplementing the supply from some other source when necessary. In order to form an opinion as to whether this pond will furnish enough water to warrant taking a supply from it in the beginning, it would be necessary for you to ascertain by surveys the size of the watershed from which its supply is derived, and to make investigations to determine how much, if any, water is liable to be lost by filtration through the ground into other ponds.

Oldham Pond will furnish an abundant supply for the town for a very long time in the future, and the analysis indicates that the water is of fairly good quality at the present time. It has only a moderate amount of color and contains about the usual amount of organic matter, and in its present condition would be a satisfactory water for all purposes of a public water supply, though not as good as either the water of Maquam Pond or Silver Lake.

The analysis of a sample of water from Furnace Pond differs but little from that of a sample collected from Oldham Pond, but Furnace Pond has no advantages which should lead to its selection as a source of water supply for Whitman.

The water of Silver Lake is practically colorless and in other respects it is a better water than any other of the waters analyzed. This would undoubtedly be a satisfactory source both with regard to quantity and quality.

Big Sandy Bottom Pond has been used for years by the towns of Abington and Rockland and has proved to be an excellent water. The quantity which this source will furnish is more than the amount of water consumed by the three towns of Abington, Rockland and Whitman at the present time, so that for a time this source might be sufficient for all of the towns, but at a later period it would be necessary either to supplement the supply from some other source or for one of the towns to introduce an independent supply.

The information now in possession of the Board with regard to the proposed sources of water supply is too limited to enable it to advise as to the most appropriate source for the town, and it makes this preliminary reply at the present time because it understands that it is desired for use at a town meeting to be held soon. The Board would advise that a survey be made, as before suggested, to determine the size of the watershed of Maquam Pond, and that analyses should be made monthly of the waters of Maquam and Oldham ponds and of Silver Lake to determine the relative quality of these waters throughout the summer. The State Board of Health will co-operate with you by causing these analyses to be made if you will collect the samples of water, and will advise you further with regard to the proposed sources if you so request.

SEWERAGE AND SEWAGE DISPOSAL.

The following is the substance of the action of the Board in reply to applications for advice relative to sewerage and sewage disposal: —

ANDOVER. The sewer commissioners of Andover, having been authorized by the town to report a plan of sewerage to the town, applied to the State Board of Health, June 8, 1893, stating that before reporting a general plan to the town they desired to know whether such a plan, involving the discharge of crude sewage into the Shawsheen River, would be approved by the State Board of Health. The Board replied as follows: —

BOSTON, July 7, 1893.

The Board is of opinion that, while it is not permissible to discharge the sewage of any large portion of the town into this river, it may be permissible for the present to discharge the sewage from the low land bordering the river into the river below the dam at Frye Village. In making a sewerage plan, therefore, provision should be made for carrying as much of the sewage of the town as can be conveyed by gravity, either to suitable porous land, where it can be purified by filtration before being discharged into the Shawsheen River, or to the Merrimack River.

ATTLEBOROUGH. The committee on drainage of the town of Attleborough applied to the State Board of Health, Jan. 16, 1893, for its advice relative to "the drainage of that portion of the village and town located on the watershed of Thacher Brook." The Board replied as follows: —

BOSTON, Feb. 6, 1893.

The plan submitted shows the general character of the proposed improvement, which provides for lowering the channel of Thacher Brook, either in its present or a new location, and the substitution, for a portion of the way, of a covered drain for the open channel.

It is understood from the statements made by your committee that it is not proposed to turn any sewage into this channel, but that the sewerage system when constructed will convey the sewage in separate pipes in some other direction. Your committee has also indicated that it is very desirable to lower the level of the ground water in the upper part of the Thacher Brook watershed and near the central portion of the village, in order to avoid damp

or wet cellars, and thereby to improve the sanitary condition of this portion of the town. The high level of the ground water in this part of the village is also shown upon a plan previously submitted to the Board giving the level of the ground water.

The Board finds that the plan now proposed is one to be commended. It is certainly very desirable, for sanitary reasons, that the level of the ground water in the built-up portions of this watershed should be lowered, and it is wise to provide for the improvement of the lower portions of this brook before the design and location of a new channel are hampered and the cost increased by the construction of streets and buildings in the vicinity of the brook.

In addition to the improvement of the main channel the plan also indicates where branch drains emptying into the brook may be built in the streets in its vicinity. It would be desirable before constructing these drains that a complete system of sewerage should be designed for at least this portion of the town, both because the level of the ground water might be lowered by underdrains placed beneath the sewers, thereby rendering separate drainage channels unnecessary, and because the drains might otherwise be placed at such a height as to interfere with the proper grading of the system of sewers. These suggestions with regard to the branch drains may also be applicable to the extreme upper end of the main drain.

BRAINTREE. The committee on sewerage of Braintree applied to the State Board of Health June 5, 1893, for advice relative to a proposed system of sewerage for that town, and as to the comparative merits of certain areas proposed for sewage disposal. The Board replied as follows: —

BOSTON, July 6, 1893.

In this application you outline the general features of a proposed system for collecting the sewage, and suggest, as a method of disposal, pumping it to land where it can be purified. You then ask that the Board will cause the different tracts of land which are available for sewage disposal to be examined at as early a day as possible, and that the Board advise you regarding them.

Three tracts were called to the attention of the Board, one situated on the north-westerly side of Plain Street, just north of the Plymouth branch of the Old Colony Railroad, known as the Plain Street lot, another in the south-westerly part of the town, known as the Mayflower Park lot, and a third in the north-westerly portion of the town, known as the Collins Farm lot.

The Collins Farm lot is unsuitable for this purpose on account of its being located where the effluent from the sewage would find its way both into the present water supply of the city of Quincy and into the territory from which this city was authorized by the Legislature in 1891 to take an additional water supply.

At the Plain Street lot the test pits indicated that the material is of excellent quality for filtering sewage, and the principal objections to it are its proximity to the village of South Braintree and the limited area of suitable land which is available at this place. It is also an objection to this lot, though to a less extent than to the others, that it requires the sewage to be pumped a long distance from the lowest point in the town (where a pumping station would naturally be located), and to quite a high elevation.

At the Mayflower Park lot the test pits indicated that in addition to the coarser sand and gravel there were layers of very fine sand, which, while not preventing the use of the lot for the filtration of sewage, would require it to be applied in smaller quantities per acre, and would therefore require a greater amount of land to dispose of the sewage. The principal objections to the lot are its proximity to several houses, its limited area and the very great distance which the sewage would have to be pumped to reach it.

The amount of land required to purify the sewage of Braintree by intermittent filtration would depend both upon the quality of the land and upon the amount of sewage. In a general way it may be said that from 6 to 10 acres of filter-beds would meet all requirements for a few years, and that it is desirable to have not less than 20 or 30 acres in all to provide for future growth. It does not seem probable that this amount of land can be made available at either the Mayflower Park or the Plain Street location.

As a general result of this preliminary examination the Board is of opinion that, before adopting either of the tracts brought to its attention, it would be advisable for the town to cause examinations to be made to ascertain if a more satisfactory disposal of the sewage cannot be effected by discharging it into the sea at some suitable outlet. The nearness of the village of Weymouth to the lowest point in Braintree suggests that the interests of both communities might be served by united action by the towns of Weymouth and Braintree in the construction of an outlet to the sea; but even if it should be built by Braintree alone it may be cheaper and more satisfactory than the disposal of the sewage upon any of the areas examined up to the present time.

BROCKTON. The sewerage commissioners of Brockton applied to the Board, Sept. 14, 1892, for its advice relative

to the proposed plan of sewerage and sewage disposal for that city. The completed plan was submitted Jan. 10, 1893. The Board replied as follows: —

BOSTON, Feb. 2, 1893.

The general features of the plan submitted are, first, a system of sewers within the city designed to take sewage only, and from which the ground water is to be excluded, both by placing an underdrain beneath each sewer to remove the ground water, and by thorough construction to make the joints of the sewers water-tight; second, a pumping station in the southerly part of the city to lift the sewage from a receiving reservoir into which the main sewer empties and which will store the sewage flowing through the night, and force it through an iron pipe to the Muster Field, so called; third, a series of filter-beds covering an area of about 23 acres upon that portion of the field lying within the limits of the city of Brockton.

The exclusion of all storm water from the sewers, as proposed by you, is undoubtedly the best course to adopt on account of the smaller sizes of the sewers required and the less quantity of sewage to be stored, pumped and purified. The proposition to place underdrains beneath each sewer so as to remove the ground water and prevent it from entering the sewers is also to be commended for the same reason, and because of the great improvement in the sanitary conditions within the city, which will result from lowering the ground-water level. Judging from the experience in other places it is probable that if these underdrains were omitted so much ground water would find its way into the sewers that the amount of sewage to be taken care of would be doubled or trebled, which would require a corresponding increase in the capacity of the main sewers, receiving reservoir, pumping plant and force main, and a considerably larger area of filter-beds. It would also increase the annual cost of pumping, all of which would offset in part, if not wholly, the additional cost of the system of underdrains.

It is obvious that the pumping station, if located within the city limits, cannot with advantage be moved much, if any, from its present location. The proximity of dwellings will, however, make it necessary, in order that there may be no offence in the neighborhood, to provide for ventilation into the chimney from the tank, receiving reservoir, sewer, pump-well, and all other places from which offensive odors might be given off, and to make all other necessary provision to prevent offence from any of the operations carried on at the pumping station. It is understood that these matters have already been carefully considered in the preparation of your plans. With due care in designing and maintain-

ing the works, the Board is of opinion that a pumping station should not be a source of offence to the neighborhood.

The provision of an overflow from the receiving reservoir and of blow-offs from depressions in the force main, where it crosses under the Salisbury Plain and Coweeset rivers, is a wise precaution; but these should be considered only as a provision for unforeseen emergencies and should never be used in the ordinary operation of the works.

The ground where the filter-beds are to be located has been very thoroughly examined by means of test pits. The material is of excellent quality for the filtration of sewage and the water level in the ground is at a considerable distance below its surface. These natural features, together with the careful manner in which it is proposed to construct the beds and their appurtenances, will permit them to be used for the disposal of an unusually large amount of sewage.

It has also been found, since the water supplied to the city has been pumped, and therefore measured, that the amount of water consumed per inhabitant is unusually small; and the amount of sewage will also be unusually small, in proportion to the population, if the ground water is kept out of the sewers, as is now proposed.

All of these facts lead the Board to conclude that the area to be used for filtration, although smaller than it is customary to recommend, will be sufficient for at least the first few years of the operation of the works, after which it will be necessary to extend the area.

The land in Brockton, lying easterly of the proposed filter-beds, which slopes from Pearl Street to the cranberry meadow, might be used to a limited extent for filtering sewage, but the test pits show that layers of an impervious clayey material are found in many places at from 3½ to 6½ feet below the surface and that the water stands in the ground much nearer the surface than on the other side of the street. This land could only be used to dispose of a comparatively small amount of sewage. The land in Brockton north of and across Daley Brook from the proposed filter-beds is better than that on the easterly side of Pearl Street but not as good as that where the filter-beds are located. This land would be fairly well adapted for the filtration of sewage.

The best land in this vicinity for the extension of the filter-beds lies just west of them, within the limits of the town of Easton. This land is similar in character to that where the filter-beds now proposed are located and is superior in quality, topography, character of material and distance from habitations to the land either east or north of them.

Since the proposed plan involved the taking of certain land within the limits of the city, further action of the Board was required under the provisions of chapter 124 of the Acts of 1890. A public hearing was therefore held by the Board, after which the following reply was sent to the mayor of Brockton: —

BOSTON, April 17, 1893.

The State Board of Health has received your petition dated March 25, 1893, made in behalf of the city of Brockton under the authority of chapter 124 of the Acts of 1890, entitled "An Act providing for the purchase or taking of land by cities and towns for the purification and disposal of sewage," asking the Board to approve the purchase or taking by said city of certain lands in Brockton for the purification and disposal of its sewage. Said lands are described in said petition and shown on an accompanying plan, as follows: "24 acres and 128.9 rods, being lands of Charles C. Manley; 20 acres and 58.7 rods, being lands of heirs of Salmon Copeland; 1 acre, being lands of David Frost; 2 acres and 73.28 rods, being lands of Milo Manley; 121.77 rods, being lands of Augustus Remick; 2 acres and 70.25 rods, being lands of George Howard."

In response to this petition the Board gave a public hearing at its office in Boston, on April 10, 1893, after due notice of said hearing by publication in the Brockton "Enterprise" and Brockton "Dispatch." Having thus complied with the requirements of the law the Board after due consideration herewith approves the purchase or taking of the premises described in said petition and shown upon the plan which accompanied it.

FRAMINGHAM. The selectmen of Framingham applied to the Board for advice relative to a proposed plan for the disposal of the water of the underdrain of the sewerage system of South Framingham, by pumping and final discharge into Bannister Brook. The Board replied as follows: —

BOSTON, Feb. 6, 1893.

Your application to the State Board of Health dated Jan. 23, 1893, for advice with regard to the disposal of the water, which is now discharged from the underdrain beneath the Framingham sewers into the water supply of Boston, by pumping this water into Bannister Brook at a point north of Hartford Street, beyond the watershed from which said supply is derived, has been carefully considered

The opinion of the Board with regard to the desirability of diverting this water from the water supply of Boston has already been given in its reply to the Board of Selectmen of Framingham dated Sept. 2, 1890.

With regard to the method of disposal now proposed, the principal features from a sanitary stand-point are the open reservoir near the pumping station, in which is to be stored the water from the underdrain during the night or at such other times as the pumps are not in operation, and the location of the final point of discharge. While it is not probable that the open reservoir will prove objectionable in any way yet the Board considers it advisable that it should be made as small as is consistent with a fair degree of economy in pumping. The capacity stated in the report which accompanied the application seems unnecessarily large.

With regard to the final disposal of the water from the underdrain by discharging it into the upper end of Bannister Brook north of Hartford Street, and beyond the watershed from which the city of Boston derives its supply, the Board is of opinion that this method of disposal is permissible for the present; but if the character of the water should deteriorate it may become necessary to discharge it upon a small filtering area, and it would be well to have the outlet where two or three acres of suitable filtering material may be secured.

HOLYOKE. The mayor of Holyoke applied to the State Board of Health, Feb. 13, 1893, for advice relative to a system of sewerage and sewage disposal for the villages of Elmwood, Oakdale and Springdale, having an outlet into the Connecticut River, opposite the trotting park in the lower part of the city. The Board replied as follows: —

BOSTON, March 2, 1893.

The Board is of the opinion that the sewage of these sections of your city may for the present be discharged into the river at the place indicated, but advises that the lower portion of the sewer should be so designed and constructed that the dry weather flow will be carried well out into the river by means of a pipe of moderate size leading from the bottom of the sewer, thereby preventing the fouling of the shore.

LEICESTER. The water commissioners of the water supply district of Leicester applied to the Board, Jan. 23, 1893, for advice as to a plan of sewerage and sewage disposal for

the village of Leicester. At a later date, March 1, they submitted a legislative document (House Document 385), stating that the committee on drainage requested that the bill accompanying the petition of the commissioners should be accompanied with the advice of the State Board of Health. The Board replied to this application as follows :—

BOSTON, March 3, 1893.

In reply to your request of March 1, relative to the application dated Jan. 23, 1893, of the Leicester Water Supply District, for advice in the matter of the disposal of the sewage of said district, the Board would state that it will be impracticable to advise until the snow disappears, so that a proper examination of the ground can be made.

With regard to the other matter mentioned, namely, the bill (House Document No. 385) extending the authority of the water commissioners of the district so that they shall also be a board of commissioners of main drains, common sewers, sidewalks and cross-walks, and providing that the district may raise money for carrying out the provisions of the act, the principal object appears to be to confer powers upon the district and its water commissioners with regard to the construction of main drains, common sewers, sidewalks and cross-walks, similar to those already possessed by towns and their selectmen. So far as the bill provides for the transfer of power from the town and its selectmen to the district and its water commissioners, the Board does not consider it within its province to advise.

In looking at the provisions of the bill in other respects, it is noticed that while it provides for the construction of main drains and common sewers, and for taking the land which may be necessary therefor, it does not authorize the construction of sewage disposal works or the taking of land for this purpose should the purification of the sewage be found necessary. The Board would therefore suggest that the bill might with advantage be modified so as to give the required authority in these respects, and herewith transmits a copy of the bill with suggested modifications to accomplish this result.

Should the Committee on Drainage think it advisable to limit the power granted to the water supply district with a view to preventing any improper disposal of the sewage, it might require the system of sewerage adopted and the land taken for sewage disposal, should any be required, to be subject to the approval of the State Board of Health. This might be accomplished by adding after the word "therefore" in section 5, line 8 :—

Provided, however, that any system or systems of sewerage, drainage or sewage disposal constructed under the provisions of this act shall be in general accordance with some plan or plans approved by the State Board of Health, and no land shall be taken for sewage disposal purposes without the approval of said Board.

The Committee on Drainage may also desire to restrict the territory within which land can be taken, by adding after the word "land," in section 5, line 7, the words "within the limits of the town of Leicester."

The final reply of the Board relative to this plan of sewage disposal was as follows: —

BOSTON, June 1, 1893.

The situation of the village upon the hill is such that nearly all of the sewage can be carried by a single system to the westerly side of the town in the vicinity of Rawson Brook, so called, or it is feasible to provide two systems, one of which would convey the sewage of rather more than half of the village to the above indicated location on the westerly side of the town, while the other would take the sewage from the remainder of the village in an easterly direction. An examination of the whole territory indicated that it would be well to take as much sewage as possible in a westerly direction to a point near the Rawson Brook.

After considering all of the conditions affecting the discharge of the sewage into Rawson Brook, the Board has reached the conclusion that such discharge should not be permitted even in the beginning until the sewage had been at least partially purified by the removal of the greater portion of the suspended matter. In the future a more complete purification of the sewage may be found necessary.

The best method of purification cannot be determined without a more extended examination of the ground than it is feasible for this Board to have made, and your town is therefore advised to employ a competent engineer to make the necessary surveys and devise a system for the purification of the sewage to at least the extent above indicated. The Board will advise further with regard to such system when the plans are submitted by you.

Where sewage is to be purified the smaller the amount of water to be taken care of, the less the difficulty of purification. The Board therefore commends your plan for adopting a system of sewers from which all storm water is to be excluded, and would further advise the exclusion of as much ground water as it is feasible to exclude.

The town of Leicester, having obtained an act from the Legislature requiring the approval of its plans by the State Board of Health (chap. 181, Acts of 1893), submitted plans to the Board, June 30, 1893, a statement of which, together with the approval of the Board, are as follows: —

BOSTON, Dec. 30, 1893.

Under the provisious of chapter 181 of the Acts of 1893, entitled "An Act to authorize the Leicester Water Supply District to construct and maintain a system of sewerage and drainage," the State Board of Health received from you on June 30, 1893, a written statement of your plan for the sewerage of the village of Leicester. This statement of your plan, as subsequently amended and submitted in a new draft dated Dec. 22, 1893, is as follows: —

13 BEACON STREET, BOSTON, MASS.

To the State Board of Health.

The water commissioners of the Leicester Water Supply District having received your reply of June 1, 1893, to their application for advice in relation to the disposal of the sewage of the village of Leicester, submit, for your approval, the following plans for its disposal.

In accordance with your suggestion, we propose to carry the sewage as far as possible to the westerly side of the village, and remove all the organic matter in suspension, so far as practicable, before discharging the effluent into Rawson Brook.

To accomplish this end, the separate water carriage system is to be adopted, to the extent of excluding all street or storm water, roof water and ground water, so far as feasible, the sewers to be flushed only when necessary with clean water from the mains.

The suspended matter is to be removed, as far as practicable, by allowing the heavier portion to settle in the tank (to be hereafter described), and by mechanical straining, if necessary, of the lighter part.

In order that the effluent may contain the smallest possible quantity of organic matter in solution, the separation is to be effected while the sewage is fresh.

The natural conditions of the location of the village on the slope of a hill are to be utilized as far as practicable by laying the sewers in accordance with approved forms of sewerage construction, to line and grade, with manholes at material changes of line and grade, at points of intersecting sewers, and wherever necessary, so as to insure easy cleaning out, and the most rapid flow and concentration of the sewage to the point of disposal.

For this purpose, 8-inch, 9-inch and 10-inch Akron salt-glazed pipe is to be used. Ground water is to be excluded by using cast-iron pipe when crossing wet, swampy land not easily drained outside of the highway, and by carefully making the joints and plugging the branches for particular sewers.

All the sewage for the present is to be collected at a point on Pine Street, 1,100 feet south of Main Street, and thence carried in a 10-inch pipe, laid at a grade of about 0.4 per cent., in a southwesterly direction, as shown by an accompanying plan, a distance of about 1,250 feet, to the top of a small knoll, and there discharged into a settling tank.

This tank is to be built either of brick or field stone, laid in cement mortar and plastered on the inside. It is to be covered with a roof or building. It is to contain not less than 600 cubic feet of sewage.

The overflow pipe from the tank is to be on the opposite side from where the sewage enters, and provision is to be made for breaking the force of the stream which enters the tank, so as to make the sewage flow quietly through it, and for preventing the floating scum from passing out through the overflow pipe.

The sewage passing from the tank is to be further purified as far as practicable by flowing it over land, or through a series of ditches, to Rawson Brook; but provision will be made so that the sewage will not have to run continuously in any one channel.

At the bottom of the tank an 8-inch gate connection with an 8-inch pipe is to be laid at a down grade of about one foot to the hundred to the point of discharge. Through this pipe the sewage or sludge which settles at the bottom of the tank is to be discharged once or twice a week, as may be necessary, upon ground thoroughly underdrained and levelled, so as to have a slight downward pitch from the point of discharge. This ground is to be ridged around the outer edge, so that the sludge may be distributed somewhat evenly over the surface. After the water which it contains has percolated through the drained surface, the solid refuse is to be carted away. Two or three beds of this kind will be prepared to be used alternately, and provision will be made for discharging the sludge brought by the 8-inch pipe upon them.

By extending the 8-inch pipe further in a southerly direction, other sludge beds can be prepared when necessary to meet future requirements.

It is proposed to acquire the knoll or ridge upon which the tank is to be located, and other knolls or ridges southwesterly therefrom, and all of the land between these knolls or ridges and Rawson

Brook, for the disposal of the sewage, and to purify the sewage upon this land as far as it may be found practicable to do so.

(Signed) H. O. SMITH,
C. W. WARREN,
D. BEMIS,
Water Commissioners.

LEICESTER, Dec. 22, 1893.

The Board has caused a careful examination of the foregoing plan submitted by you to be made, and hereby approves said plan.

NORTH BROOKFIELD. The selectmen of North Brookfield applied to the State Board of Health, July 23, 1893, for advice relative to an extension of their existing system of sewerage and to an improved method of sewage disposal. The Board replied as follows: —

BOSTON, Sept. 8, 1893.

The plan, as set forth by the application and plans submitted, provides for the extension of the present main sewer to the northerly end of the town farm, the lower portion of said sewer to be an inverted siphon of iron pipe. At the outlet of the siphon a settling tank is shown, and provision is made for cleaning it by discharging its contents through an 8-inch pipe extending from the bottom of the tank down the hill to a sludge bed. The plan also shows another pipe extending down the hill, to serve as a main carrier of a system for distributing the settled sewage. The other carriers are not shown, but it is understood that they are to consist of ditches dug along the hillside, and having only a slight slope from the main carrier to their lower ends. It is further stated that the sewage can be turned upon about 17 acres of mowing and tillage land of a sandy nature, and thus dispose of the same by broad irrigation, and that there is other land upon the town farm which could be easily used in the future if necessary. The quantity of sewage at present is said to be about 50,000 gallons per day.

Under the conditions which exist in the present case it is advisable to screen the sewage, rather than to settle it, and thus avoid the possibility of producing offensive odors when the contents of the settling tank are discharged upon the sludge bed. The inverted siphon can undoubtedly be made to operate as now proposed, but it would be a desirable safeguard to adopt, to place screens above the entrance of the siphon, and thus prevent any large substances from getting into it. The satisfactory operation of the siphon would also be further insured by constructing an automatic flush tank above it, so that the sewage, instead of flow-

ing through it continuously in a sluggish stream, would pass through intermittently with a high velocity, and thus prevent the formation of putrefying deposits in the pipe. This intermittent discharge of the sewage would also facilitate its distribution over the land. The use of screens may be objected to on the ground that they will require excessive attention, but this objection can be overcome to a large extent by providing a very large screen area.

The changes as suggested would tend to decrease the cost of the work, as the screen chamber and flush tank should not cost any more than, if as much as, the proposed settling tank, sludge pipe and sludge bed; and by screening the sewage so that no large substances would enter the siphon pipe it would be feasible to reduce the diameter of this pipe to 8 inches.

With the present knowledge with regard to sewage disposal there would be a greater certainty of success if the sewage was discharged upon beds prepared upon the most porous part of the town land and disposed of by intermittent filtration. The proper preparation of these beds would include the removal of the black and yellow loam at the surface and the grading of the beds, so that the sewage could be evenly distributed upon them. It is probable, however, that, with the small quantity of sewage to be taken care of, satisfactory results may be obtained by the system of broad irrigation proposed by the town, and with less expense than by intermittent filtration, and the Board therefore thinks it proper that the town should begin to dispose of the sewage by broad irrigation. It would advise, however, that even in the beginning, several small beds, having an aggregate area of not less than one-half an acre, should be carefully prepared for intermittent filtration by the removal of the soil, for use at times when it is impracticable or inconvenient to dispose of the sewage by broad irrigation.

Where the sewage is disposed of upon a hillside by broad irrigation, there will be a tendency, if the sewage is allowed to flow long in one place, for it to gather in a stream and flow down the hill. To meet this contingency a large, level, intercepting ditch should be constructed around the lower part of the land, not less than 5 feet above the brook, to intercept streams of this character and prevent them from flowing unfiltered into the brook. Around other margins of the field small ditches should be dug to prevent the sewage from flowing off in these directions and convey it to the large intercepting ditch just mentioned.

In all cases of sewage disposal, and particularly where broad irrigation is adopted, the attainment of successful results depends to a very large extent upon the intelligent care taken to effect a proper distribution of the sewage.

PITTSFIELD. The city of Pittsfield presented to the Board, May 11, 1891, a plan of sewerage and sewage disposal, under the provisions of chapter 357, Acts of 1890, providing for the permanent disposal of sewage of the city by filtration upon land in the valley of the Housatonic River, with a temporary outlet into the river during the construction of the works. This plan was approved by the Board, May 12, 1891, with the provision that the direct discharge into the river should not continue after June 1, 1900.

On the 27th of December, 1892, the Sewer Commissioners applied to the Board requesting the following modification of the plan approved by the Board: "To strike out so much of said plan as designates specific areas of land for the permanent disposition of said sewage, and by striking out so much of said plan as provides that after the date therein specified all sewage is to be pumped to filtering fields across the river and there disposed of by intermittent filtration, and by inserting instead thereof a provision that after said date all sewage is to be permanently disposed of by such methods as the State Board of Health shall then approve." The Board replied to this application as follows: —

BOSTON, Jan. 10, 1893.

By the plan approved by the State Board of Health, above referred to, the Board permitted the use of the Housatonic River for the discharge of the sewage of Pittsfield until the year 1900, and after that date the sewage was to be cared for upon filtering areas of land and the discharge into the river stopped. The use of the river was therefore but for a brief period, and the main features of the general plan presented by the city of Pittsfield, and approved by this Board, provided for the ultimate care of the sewage upon the filtering areas. The changes now asked for, if approved by this Board, would leave the city of Pittsfield without provision for its future disposal of sewage other than the river. The Board is of opinion that such a course is not advisable for the city, nor does the Board feel it will do its duty should it approve any plan not fully providing for the future proper sanitary care of the city's sewage. The Board therefore cannot approve the amendments as proposed, but will consider any further plans in regard to the ultimate disposal of the sewage which the city may desire to present.

PLYMOUTH. The committee on sewerage of the town of Plymouth applied to the Board, March 30, 1893, for its advice

relative to a plan of sewerage and sewage disposal for that town. The Board replied as follows: —

BOSTON, June 14, 1893.

The plan referred to shows the outlines of a system of sewerage for the portion of the town from which sewage can be brought by marginal intercepting sewers to a point in Water Street just north of all wharves, and a 12-inch cast-iron pipe extending from this connecting point out into the harbor to the North Guzzle, so called. It is understood that the plan proposes the admission of storm water into the sewers from the main street of the town, but that elsewhere it is to be excluded. In order to provide for the disposal of the storm water, storm overflows from the marginal sewer are provided at four points along the shore.

The only important feature in which the Board advises a change is in the outlet pipe, which, in the opinion of the Board, should be changed so as to reach the Guzzle at a point as far from the shore as it is practicable to extend the pipe, but not more than 1,500 feet. The limit of 1,500 feet is mentioned because it is doubtful if a pipe longer than this could be kept free from deposits. In making the pipe longer, as advised, its size should be increased to 14 inches, which will not only offset the loss of capacity due to the greater friction of a longer pipe, but will also give a slight addition to the capacity, which is desirable.

The sizes and inclinations of the intercepting sewers appear to have been judiciously chosen, so far as can be judged from the preliminary plan submitted. These sewers of necessity are placed at a low level as compared with high tide, and have rather low grades, so that they may not prove wholly self-cleansing, but, even if they should not, the amount of care required to keep them clean would not be excessive. The cleaning of the southern branch of the intercepting sewer may be facilitated by the construction of an inlet as large as the sewer itself from the lower millpond on Town Brook, provided the millpond is at a sufficient elevation, this inlet to be used from time to time at low tide for flushing the sewer.

As a precaution against the clogging of the outlet pipe the Board would suggest the construction of a small chamber at its upper end, where it receives the sewage from the intercepting sewers. The bottom of this chamber should be depressed so as to act as a settling basin and catch any heavy material brought down by the sewers. It could be built in the street, but it would be better to construct it just outside the street lines and make it easily accessible. A gate at the upper end of the pipe, by which the water or

sewage could be held back in the sewers and then let out suddenly at low tide to flush the pipe, would be an advantage.

SPENCER. The superintendent of sewers of Spencer applied to the Board, June 1, 1893, for its advice relative to a system of sewage disposal upon land in the valley of Seven Mile River. The Board replied as follows: —

BOSTON, Dec. 8, 1893.

The Board finds from the statements contained in your application, and from the examinations made by one of its engineers, that the topography of the town is such that nearly all of the sewage can be collected by a system of sewers with a main sewer leading toward the Seven Mile River at a point south-westerly from the centre of the town, that the main sewer and a large part of the tributary sewers of this system have already been built, and that the sewage is now discharging into the river. It is the sewage from this main system which you propose to deal with at present.

The sewers already built are for the most part intended to take sewage only, but at a few points catch-basins have been built through which considerable storm water is admitted to the sewers; and there is also a considerable amount of ground water finding its way into them, which materially increases the volume of sewage to be taken care of. The sewers also receive, in addition to the sewage proper, certain waste matters from the gas works in the town, which make the sewage particularly offensive and destroy the vegetation in the vicinity of the sewer outlet.

The town is situated on high land, and the main sewer falls rapidly until it reaches the lower land bordering the river. By intercepting the sewage before it reaches too low a level the sewage can be discharged by gravity upon land at a sufficient height above the river for sewage filtration. The suggestion has been made by you that the town now owns ten acres of gravelly land near the river, through which the present main sewer passes, which might be used for the disposal of sewage by intermittent filtration; and that there are also about three acres of similar land adjoining the town lot on the south which might be used if additional area was required.

The material of the town lot, as determined by several test pits and by an examination of the surface of the ground, is of suitable quality for the disposal of sewage by the method suggested. The proper preparation of the lot for sewage disposal would involve the removal of the surface loam and the grading of the land into beds of suitable size, having a surface of porous sand or gravel.

In order to make the lower portions of the land available it would be necessary, after removing the surface loam, to raise them by filling with porous sand or gravel to a level six feet above ordinary high water in the river. The filter beds which have surfaces not more than 8 feet above the river should be underdrained. By taking the sand or gravel for this filling from the higher portions of the land and by building a few hundred feet of sewer in Main Street, so that the sewage will reach the lot at a higher level, it will be feasible to utilize all of the gravelly land, including the three acres lying south of the town lot.

It is desirable to restrict as far as practicable the amount of sewage to be taken care of, and in order to do this the surface water which now enters the sewers through the catch basins in the streets should be disposed of in some other way. It is also desirable to diminish the amount of ground water, if, upon examination, it should be found feasible to do so. Should any large amount of ground water be found to enter the main sewer, or should it be found desirable to continue to dispose of the storm water through underground channels, it may be best to lay a new main sewer of much smaller size than the present one to take the sewage, reserving the present main sewer for the discharge of surface and ground water. The surface water which would naturally flow from adjacent high land upon the filter beds should also be collected and disposed of in such a way that it will not tend to saturate the beds. It may be feasible to turn this water into the lower portion of the present main sewer below the point where the sewage will be diverted from it to the filter beds.

It may be said, with regard to the disposal of the sewage of the town by intermittent filtration, that it is not probable that the results will be satisfactory unless the wastes from the gas works are excluded from the sewers, or, before being admitted, are treated in such a way as to make them inoffensive, and to remove all tarry or oily substances which would tend to clog the filter bed.

The area of suitable land at the town lot and the lot adjacent to it is smaller than is desirable, considering the large amount of ground water which finds its way into the sewers, and the increasing quantity of sewage which will enter the sewers as they are extended and the town increases in population. If the ground water could be excluded from the sewers, the area would be sufficient until the population of the town is considerably larger than at present.

In view of the somewhat limited area of land available at and near the town lot, examinations were made to determine whether additional land was available, and a tract was found, lying in a

south-westerly direction from the town lot, between the Brookfield road and the river, just beyond the cemetery, which appeared from a surface examination to be suitable for sewage filtration. This land is considerably higher than the river, but it is lower than the main sewer in Main Street, a short distance from the town lot, and the sewage could be conveyed to it through an iron pipe which would run full and under pressure. The lowest point in this pipe would be at the corner of Meadow and Main streets, nearly opposite the town lot, so that the pipe could be emptied frequently upon filter beds on the town lot, and thus kept clean. This tract of land is of suitable quality, and probably other land in this vicinity could be made available for the disposal of sewage.

While the town lot has a decided advantage, owing to its present ownership by the town and the ease with which sewage can be turned upon it, it will obviously be quite expensive to grade it and the small lot south of it so that the whole area of these lots will be available for sewage disposal, and unless the amount of sewage is materially diminished by the exclusion of ground water, it will be necessary to provide additional filtering area before long. It is therefore recommended that the town lot should not be finally adopted as the only site for filter beds until the other tract of land beyond the cemetery has been more carefully investigated, by digging test pits to ascertain if the material is porous and suitable for filtration; and, if so, whether it will not be cheaper to prepare the required area of filter beds partly at the town lot and partly at the lot beyond the cemetery; or, if not cheaper, whether it may not be desirable to control this second lot from the beginning, so as to have an opportunity to extend the filter-beds whenever it becomes necessary.

When you have the results of further surveys and estimates, or more definite plans of sewage disposal to submit, the Board will advise you further in this matter.

The Board is of the opinion that the discharge of the sewage directly into the Seven Mile River should be discontinued.

WESTBOROUGH. The committee on sewerage of the town of Westborough presented a general plan for the sewage disposal of the town, Feb. 3, 1890, which the Board approved (Senate Document 4, 1891, page 18). By a general Act of the Legislature of 1890, chap. 124, it was provided that land might be taken for sewage disposal with the approval of the State Board of Health after a public hearing. Under the provisions of this Act the selectmen applied to the Board

June 22, 1891. A hearing was held July 7, 1891, and the location submitted by the town was approved by the Board, July 8, 1891 (Senate Document 4, 1892, page 49).

In the following year, April 16, 1892, the selectmen of Westborough presented a plan, which, after due consideration, the Board deemed unsatisfactory and expressed such opinion in a communication to the selectmen, Nov. 3, 1892 (Senate Document 4, 1893, page 6), stating the conditions essential to success.

The selectmen again applied to the Board, Sept. 18, 1893, stating that the advice of the Board had not been carried out, and requesting the Board to "make an examination of the present sewage-disposal works of Westborough and advise the town further in the matter of sewage disposal." The Board replied as follows: —

BOSTON, Oct. 26, 1893.

In compliance with this request the Board has caused an examination of your present works to be made by one of its engineers. He finds that you have prepared filter-beds, having an area of a little more than two acres, by filling porous sand and gravel to a depth of from one to two and a half feet upon land from which the greater part if not all of the loam had been removed. From an examination by means of test pits dug at various points in the filter beds, he finds that the material beneath the upper porous layer is an extremely fine sand which not only remains saturated with water, but also keeps the porous material above it saturated for weeks after the discharge of sewage upon it has ceased. These conditions are unsuitable for the purification of sewage; and a very small quantity of sewage only could be disposed of upon these shallow beds if they were underdrained.

It was also found that a portion of the sewage was disposed of by being turned into a gravel pit, near the carrier, until the sewage stood in the pit to a depth of several feet, when it filtered into the ground quite rapidly, and the water reappeared in the form of a spring, a short distance away, clear but not thoroughly purified. It is highly improbable that this method of disposal would continue to give even as good results as at present for any long time in the future if any large proportion of the sewage should be turned into this pit. The rapidity with which the sewage disappears shows that the ground is porous in this vicinity, and that a good filter-bed might be prepared here which would successfully dispose of a portion of the sewage.

In reply to a previous application made by your board, the State

Board of Health sent to you on Nov. 3, 1892, a communication containing its advice in a general way as to what the town should do to properly dispose of its sewage. This advice, which the Board has no reason to modify, is as follows: —

The Board . . . . advises that the town should prepare filter-beds having a total area of not less than five acres for the disposal of its sewage. These beds should consist of sufficiently porous material to properly filter the sewage, and if of such a character or so situated that the ground-water level will not remain at least five feet below the surface of the beds, they should be efficiently underdrained.

The most economical method of preparing beds such as are here described is a matter which requires investigation. If a portion of your land can be found where there are two or three feet of porous material above the level of the water in the Assabet River, the required height of filter-bed can be obtained by filling gravel upon this portion after the loam or any other layer of very fine material which may be found has been stripped from it. If such land as is here described cannot be found, it may then be necessary to prepare beds by cutting down some of the higher gravelly land to the proper level, and filling the excavated material upon the low land, both the excavated and filled areas being used for filtration. The character of the material lying on the easterly side of a narrow swamp, and also easterly from the tract belonging to the town, appears to be of suitable quality for the construction of filter-beds by the last described method.

The Board cannot give you any more specific advice than that above given as to what should be done, because it is not feasible from such examinations as are made by its engineers to obtain the accurate data upon which such advice should be based in order to avoid wasteful expenditures and unsatisfactory results.

What you should therefore do is to employ some engineer skilled in this class of work to make plans of all the territory which may be used for sewage disposal, showing the height of the ground, the level of the water in the ground and the location of the test pits, which should be sunk at frequent intervals and to a sufficient depth to determine accurately the character of the material at different places with reference to its porosity. He should also determine where and how filter-beds can be constructed at a minimum cost, which will at least meet the requirements contained in the former reply of the Board.

If you should decide to make such investigations the Board will direct its engineers to co-operate with your engineer in the matter of determining the suitability of materials obtained from test pits for filtering sewage; and when the investigation is far enough advanced and new plans are presented the Board will advise you further regarding them.

EXAMINATION OF WATER SUPPLIES.

EXAMINATION OF WATER SUPPLIES.

EXPLANATORY NOTE.

The systematic examination of the water supplies of the State was begun June 1, 1887, and has been continued up to the present time. The results for the years previous to 1893 have been published in four reports, as follows: June 1, 1887, to May 31, 1889, in the Special Report of the Board upon the Examination of Water Supplies (1890); June 1, 1889, to Dec. 31, 1890, in the Twenty-second Annual Report of the Board for the year 1890; for the years 1891 and 1892, in the Twenty-third and Twenty-fourth Annual Reports of the Board for those years. The present (Twenty-fifth Annual) report contains the results for the year 1893.

The first of these reports contained a description of each of the water supplies in the State existing at the date of that report. The later reports have described only new works and changes in existing works.

An alphabetical arrangement by towns has been adopted in this, as in previous reports. Sources of water supply are tabulated under the name of the town supplied, other waters under the name of the town in which they are situated. The analyses of water from the larger rivers not used as sources of water supply are given in a subsequent tabulation, headed "Examination of Rivers."

The chemical examinations in this report were made in the same manner as heretofore, and are presented in the tables in the same form as in the last report, except that a new determination, "Oxygen Consumed," has been added. This determination has been made for all waters this year, and appears in the tables of analyses for the first time. Owing to the space occupied by the column of "Oxygen Consumed," the "date of examination" of the samples has been omitted from the tables. The samples are usually received at the laboratory from twenty-four to forty-eight hours after collection.

All surface water and such samples of ground water as contain suspended matter are filtered through filter-paper before determining the color, the residue on evaporation and the albuminoid ammonia in solution. Some ground waters which are perfectly clear and colorless when drawn from the ground become turbid and colored on standing, in consequence of the oxidation of the iron which they contain. In these waters the residue on evaporation is determined without filtration, since this iron is an essential and not an accidental ingredient in the water. In the changes which accompany the oxidation of the iron in waters of this character, they become first cloudy (well described by the word *milky*) and finally deposit a precipitate of oxide of iron. In the cloudy condition they have a distinct color, which, while it does not have the same significance as in the case of surface waters and is only a passing phenomenon, is, nevertheless, of interest as showing a color which the water may assume while the oxidation of

the iron is in progress. When the iron is all oxidized and precipitated the water may become colorless again. Explanatory notes will be given for waters of this kind in connection with the tables of analyses.

The color of water is expressed by numbers which increase with the amount of color. The standard used is nesslerized ammonia, as described on page 531 of the Special Report upon the Examination of Water Supplies, 1890, and on page 329 of the Annual Report for 1893. Boston water, as drawn from a tap at the Institute of Technology, has had an average color for six years of 0.43. Other water supplies in the State have had an average color of from 0 to 1.45.

In cases where examinations of a source have been made with considerable regularity for several years, the averages of the results of the chemical analyses of previous years are appended to the tables of analyses for 1893.

In the microscopical examination of water there has been no change in the method employed since Nov. 6, 1890. This method was fully described in the Twenty-third Annual Report of the Board for the year 1891 (pages 395–421). Before Nov. 6, 1890, the methods employed were less perfect, so that a smaller proportion of the total number of organisms present in the water was separated from it and observed under the microscope; and, before drawing conclusions from a comparison of the microscopical examinations of waters made before and after this date, the explanatory note on page 70 of the Twenty-second Annual Report for 1890 should be read.

To indicate the amount of the so-called *Zoöglœa* observed, the number of individual masses is not counted, but an area equal to 2,500 square microns, or .0025 square millimeters, has been adopted as an arbitrary unit.

In publishing the results of the microscopical examinations the same system is followed as last year. The plants observed are classified in four groups, viz.: Diatomaceæ, Cyanophyceæ, Algæ and Fungi. The Animals observed are grouped as Rhizopoda, Infusoria, Vermes and Crustacea.

The names of the different genera in each group are given with the numbers of each per cubic centimeter, except that, to avoid making the tables excessively long, they are omitted when present only in very small numbers. It is not feasible to make with regard to omissions a single rule which will apply to all cases, because it is desirable to include smaller numbers of animals than of plants, and of the larger animals than of animals generally. Moreover, there are exceptional cases in which it is desirable to indicate the presence of even very small numbers of the more important plants or animals. Two general rules, however, have been adopted in printing the results, namely: —

1. All genera of Plants are included in which the total number observed in twelve months amounts to 6 or more per cubic centimeter, or in other words averages as much as 0.5 per month.

2. All genera of Animals are included in which the total number observed in 12 months amounts to 1.5 or more per cubic centimeter.

The larger microscopic animals, such as some of the Crustacea, are included, even when present only in very small numbers.

Fractions are generally omitted from the table, the nearest whole number of organisms per cubic centimeter being given. Where the total number of organisms observed is 0.5 or less, the fact that the organism was present is usually indicated by the abbreviation "pr.," but in the case of the larger organisms very small fractions are given.

EXAMINATION OF WATER SUPPLIES.

Water Supply of Abington and Rockland.

Chemical Examination of Water from Big Sandy Pond, Pembroke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
10032	Feb. 17	V. slight.	Slight.	0.02	2.10	0.80	.0000	.0086	.0060	.0026	.58	.0000	.0000	.1822	0.9
10058	Feb. 27	V. slight.	V. slight.	0.02	3.05	0.85	.0008	.0130	.0106	.0024	.68	.0000	.0000	.1584	0.8
10196	Mar. 31	V. slight.	Slight, white.	0.05	2.75	0.85	.0060	.0194	.0130	.0064	.58	.0030	.0001	.1825	0.5
10282	Apr. 19	Slight.	Slight.	0.08	3.00	1.20	.0000	.0132	.0112	.0020	.62	.0000	.0000	.1861	0.8
10416	May 17	V. slight.	None.	0.08	3.50	1.55	.0010	.0128	.0110	.0018	.59	.0030	.0001	.2372	0.5
10523	June 14	Slight.	Slight.	0.10	3.65	1.45	.0020	.0170	.0152	.0018	.62	.0000	.0000	.2110	0.8
10650	July 11	V. slight.	V. slight.	0.05	2.95	1.10	.0012	.0152	.0132	.0020	.63	.0050	.0000	.1971	0.5
10816	Aug. 15	Slight.	V. slight.	0.10	3.35	1.20	.0000	.0128	.0112	.0016	.62	.0000	.0000	.2870	0.4
11024	Sept. 13	Distinct.	Slight.	0.10	4.30	1.90	.0000	.0182	.0152	.0030	.66	.0000	.0000	.2340	0.8
11196	Oct. 13	V. slight.	V. slight.	0.08	3.80	1.75	.0002	.0154	.0142	.0012	.69	.0000	.0000	.1944	0.8
11343	Nov. 15	Slight.	Slight.	0.08	2.65	0.85	.0000	.0120	.0104	.0016	.65	.0030	.0000	.3029	0.8
11482	Dec. 12	Slight.	Slight.	0.10	3.15	0.80	.0006	.0176	.0156	.0020	.64	.0000	.0000	.2336	0.8
Av.	....	....	....	0.07	3.19	1.19	.0010	.0146	.0122	.0024	.63	.0012	.0000	.2130	0.5

Iron, .0048. Odor, generally vegetable or none; once only disagreeable, disappearing on heating.—— The samples were collected from a faucet at the pumping station, with the exception of No. 10,032, which was collected from the pond under the ice about 150 feet from the intake, and No. 10,650, which was collected from a drinking fountain near the center of the village of Abington.

ABINGTON AND ROCKLAND.

Microscopical Examination of Water from Big Sandy Pond, Pembroke.

[Number of organisms per cubic centimeter.]

	1892.											
	Feb.	Mar.	Apr.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	21	1	4	21	19	16	15	16	15	14	17	14
Number of sample,	10032	10058	10196	10282	10416	10523	10650	10816	11024	11196	11343	11482
PLANTS.												
Diatomaceæ,	87	163	393	114	23	405	21	36	364	90	26	125
Asterionella,	60	9	24	42	5	1	0	6	130	9	3	120
Cyclotella,	1	2	98	18	0	400	18	24	32	pr.	2	2
Fragilaria,	4	0	4	2	0	0	0	0	14	0	0	0
Melosira,	0	0	2	2	0	1	0	1	108	73	3	0
Navicula,	6	pr.	1	pr.	0	1	0	0	0	0	0	1
Stephanodiscus,	0	0	0	0	10	0	0	0	0	0	0	0
Synedra,	16	150	224	36	3	0	0	1	0	0	16	2
Tabellaria,	pr.	2	40	14	5	2	3	4	80	8	2	0
Cyanophyceæ,	7	0	0	0	0	0	0	0	0	42	pr.	50
Chroöcoccus,	7	0	0	0	0	0	0	0	0	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	0	0	0	0	50
Microcystis,	0	0	0	0	0	0	0	0	0	42	pr.	0
Algæ,	pr.	8	pr.	18	5	0	0	0	9	0	12	4
Protococcus,	0	8	0	0	5	0	0	0	9	0	10	0
Staurogenia,	0	0	pr.	0	0	0	0	0	0	0	2	4
Zoöspores,	pr.	0	0	18	0	0	0	0	0	0	0	0
ANIMALS.												
Rhizopoda, Difflugia,	0	0	0	0	0	0	0	0	pr.	0	0	1
Infusoria,	14	53	208	19	3	5	0	31	4	3	0	281
Chlamydomonas,	0	0	0	0	0	0	0	0	0	0	0	200
Dinobryon,	0	7	0	0	0	1	0	0	0	0	0	0
Dinobryon cases,	14	44	208	16	3	4	0	30	2	0	0	80
Peridinium,	pr.	2	pr.	3	0	0	0	1	2	3	0	1
Vermes,	0	1	1	0	0	pr.	0	pr.	2	0	0	0
Anurea,	0	1	1	0	0	pr.	0	0	1	0	0	0
Polyarthra,	0	0	0	0	0	0	0	pr.	1	0	0	0
Miscellaneous, Zoöglœa,	7	3	7	14	0	16	44	2	28	18	40	10
TOTAL,	115	228	609	165	31	426	65	69	407	153	78	471

WATER SUPPLY OF AMESBURY.—POWOW HILL WATER COMPANY.

Chemical Examination of Water from the Works of the Powow Hill Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
10568	June 27	V. slight, clayey.	V. slight.	0.0	6.80	.0000	.0034	.63	.1200	.0006	.0558	2.2	.0000
10569	June 27	None.	None.	0.0	11.70	.0000	.0004	.63	-	.0000	.0287	6.4	.0000

Odor, none. —— The first sample was collected from basin No. 1, which is supplied chiefly through tubular wells, and is the source from which samples have been collected in previous years. The last sample was collected from basin No. 2, a supplementary basin near No. 1.

Microscopical Examination.

No. 10568. Infusoria, *Peridinium*, pr.; *Trachelomonas*, pr.
No. 10569. Vermes, *Anurea*, pr.; *Rotatorian ova*, pr.

WATER SUPPLY OF ANDOVER.

Chemical Examination of Water from Haggett's Pond, Andover.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9892	Jan. 18	V. slight.	Slight.	0.07	3.80	1.35	.0066	.0226	.0136	.0090	.48	.0030	.0002	.2409	1.4
10043	Feb. 27	V. slight.	V. slight.	0.10	3.30	0.90	.0026	.0144	.0120	.0024	.38	.0000	.0000	.2520	1.6
10122	Mar. 15	None.	None.	0.08	3.40	1.45	.0056	.0150	.0124	.0026	.34	.0030	.0001	.1857	1.7
10262	Apr. 18	Slight.	Slight.	0.10	3.15	1.25	.0000	.0132	.0112	.0020	.29	.0000	.0000	.2920	1.1
10408	May 17	Slight.	Slight.	0.15	3.05	1.00	.0000	.0154	.0136	.0018	.34	.0090	.0001	.3212	1.0
10522	June 15	Slight.	Slight.	0.20	3.35	1.40	.0000	.0174	.0140	.0034	.31	.0030	.0000	.3383	1.1
10656	July 12	V. slight.	V. slight.	0.08	3.30	1.25	.0002	.0162	.0140	.0022	.34	.0000	.0000	.3066	1.1
10863	Aug. 17	V. slight.	V. slight.	0.08	3.55	1.90	.0000	.0156	.0124	.0032	.33	.0000	.0000	.2691	1.0
11018	Sept 13	V. slight.	V. slight.	0.08	3.10	1.30	.0000	.0142	.0126	.0016	.35	.0030	.0000	.2418	0.9
11190	Oct. 12	None.	V. slight.	0.05	3.00	1.55	.0000	.0154	.0140	.0014	.38	.0000	.0000	.2875	1.1
11345	Nov. 16	Slight.	Slight.	0.02	3.40	1.25	.0000	.0120	.0096	.0024	.37	.0030	.0000	.3195	1.6
11480	Dec. 12	V. slight.	Slight.	0.10	3.15	0.95	.0000	.0102	.0094	.0008	.31	.0000	.0000	.2600	1.1
Av.	....	....	....	0.09	3.30	1.30	.0013	.0151	.0124	.0027	.34	.0020	.0000	.2762	1.2

Iron, .0039. Odor, vegetable or none. —— Nos. 10043, 10122, 10262, 10522 and 11480 were collected from a faucet in the pumping station; the remaining samples, directly from the pond.

ANDOVER.

Microscopical Examination of Water from Haggett's Pond, Andover.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	28	16	19	18	16	15	19	14	18	17	14
Number of sample,	9892	10043	10122	10262	10408	10522	10656	10863	11018	11190	11345	11480
PLANTS.												
Diatomaceæ,	3	178	28	126	210	372	90	35	16	3	91	93
Asterionella,	0	4	3	5	106	8	0	27	13	pr.	19	22
Cyclotella,	0	156	24	44	76	360	86	6	pr.	1	19	68
Melosira,	0	0	0	4	19	0	0	0	0	2	26	0
Navicula,	pr.	0	0	3	pr.	1	pr.	0	1	0	1	1
Synedra,	1	16	1	64	7	1	4	2	1	0	4	2
Tabellaria,	2	2	0	6	2	2	0	0	1	0	22	0
Cyanophyceæ,	0	0	0	0	0	3	10	17	0	0	0	0
Anabæna,	0	0	0	0	0	2	10	6	0	0	0	0
Clathrocystis,	0	0	0	0	0	1	0	11	0	0	0	0
Algæ,	0	0	0	0	0	0	0	28	6	0	2	0
Protococcus,	0	0	0	0	0	0	0	24	6	0	0	0
Raphidium,	0	0	0	0	0	0	0	4	0	0	2	0
ANIMALS.												
Rhizopoda, Euglypha,	0	0	0	0	0	0	0	3	0	0	0	0
Infusoria,	0	0	0	5	pr.	1	pr.	4	3	pr.	1	6
Dinobryon,	0	0	0	0	0	0	0	3	0	0	0	0
Dinobryon cases,	0	0	0	4	pr.	0	0	0	0	0	0	6
Peridinium,	0	0	0	1	0	1	pr.	1	2	pr.	pr.	0
Trachelomonas,	0	0	0	0	0	0	0	0	1	pr.	1	0
Miscellaneous, Zoöglœa,	0	7	0	0	0	36	24	0	2	32	50	0
TOTAL,	3	185	28	131	210	412	124	87	27	35	144	99

WATER SUPPLY OF ARLINGTON.

The advice of the State Board of Health to the town of Arlington relative to obtaining an additional water supply for the town and improving the quality of the present supply may be found on pages 9-12 of this volume. For analyses of samples of water from the wells mentioned in the reply to the town see the twenty-fourth annual report for 1892, pages 81–82. Additional analyses of water from these wells were made in 1893, and are given in this report on page 97.

ARLINGTON.

Chemical Examination of Water from the Brook just above the Storage Reservoir of the Arlington Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9885	Jan. 16	V.slight.	Slight.	0.20	7.75	1.95	.0090	.0136	.0112	.0024	.71	.1000	.0001	.2387	3.4
10385	May 12	V.slight.	Slight.	1.10	6.20	2.45	.0012	.0208	.0176	.0032	.52	.0650	.0002	.7628	2.2
10636	July 10	Slight.	Slight.	0.20	6.60	1.90	.0016	.0116	.0102	.0014	.64	.0800	.0001	.2628	3.4
11039	Sept. 18	Slight.	V.slight.	0.18	8.45	3.05	.0002	.0086	.0062	.0024	.73	.0750	.0001	.2652	3.3
11295	Nov. 7	Slight.	V.slight.	0.95	8.90	2.55	.0024	.0202	.0186	.0016	.75	.0680	.0004	.8480	3.2
Av.	....	....	....	0.56	7.02	2.29	.0044	.0166	.0141	.0025	.58	.0722	.0002	.5107	2.9

Iron, .0149. Odor, vegetable or none; often becoming stronger on heating.—— Water from this brook is drawn into the filter-gallery beside the reservoir and is thence supplied directly to the town, making it unnecessary to draw water from the reservoir except at times when the supply from the brook and filter-gallery combined is insufficient for the use of the town.

Microscopical Examination.

Average number of organisms, 177. The greatest number in any sample was 734 in March, consisting almost entirely of *Crenothrix* and *Zoöglœa*.

Chemical Examination of Water from Tubular Test Wells at East Lexington.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1893.												
11498	Dec. 14	None.	None.	0.08	7.30	.0076	.0064	.44	.0080	.0000	.1560	4.0	.0270
11523	Dec. 19	Slight.	Slight.	0.12	7.65	.0092	.0062	.47	.0090	.0000	.1589	4.0	.0550
11552	Dec. 27	Slight.	Cons.	0.15	7.70	.0106	.0070	.48	.0180	.0007	.2100	4.6	.0330

Odor of the first sample, none; of the second, none, becoming faintly vegetable on heating; of the last, very faintly vegetable, disappearing on heating.—— The samples were collected during a pumping test from the same tubular wells that were tested last year. The test was begun on December 1, and pumping was continued at an average rate of 384 gallons per minute from 17 wells until after the second sample was collected. The third sample was collected while pumping from 13 wells at a rate of 287 gallons per minute.

Microscopical Examination.

No. 11498, no organisms. No. 11523, Fungi, *Crenothrix*, 60. Miscellaneous, *Zoöglœa*, 80. Total, 140. No. 11552, Fungi, *Crenothrix*, 64. Miscellaneous, *Zoöglœa*, 8. Total, 72.

ASHBURNHAM.

Chemical Examination of Water from Upper Naukeag Pond, Ashburnham.

[Parts per 100,000.]

Iron, .0020. Odor, none. —— The samples were collected from the pond about *four feet* beneath the surface.

Microscopical Examination of Water from Upper Naukeag Pond, Ashburnham.

[Number of organisms per cubic centimeter.]

	1898.		
	March.	April.	August.
Day of examination,	21	20	17
Number of sample,	10140	10267	10619
PLANTS.			
Diatomaceæ,	0	13	90
Asterionella,	0	0	35
Cyclotella,	0	0	52
Synedra,	0	7	0
Tabellaria,	0	6	3
Cyanophyceæ,	0	0	22
Merismopedia,	0	0	20
Nostoc,	0	0	2
Algæ,	0	pr.	105
Cosmarium,	0	pr.	2
Protococcus,	0	0	[illegible]
Raphidium,	0	0	76
Staurastrum,	0	0	2
Fungi, Glaucothrix,	0	0	7

ASHBURNHAM.

Microscopical Examination of Water from Upper Naukeag Pond, Ashburnham. — Concluded.

[Number of organisms per cubic centimeter.]

	1893.		
	March.	April.	August.
ANIMALS.			
Infusoria,	pr.	7	11
Dinobryon,	0	6	0
Dinobryon cases,	pr.	0	10
Peridinium,	0	1	1
Vermes, Anuræa,	4	0	0
Miscellaneous, Zoöglœa,	0	36	36
TOTAL,	4	56	271

WATER SUPPLY OF ATTLEBOROUGH.

In April, 1892, the town of Attleborough introduced water from a new source and abandoned its former source of supply near the Ten Mile River, in the thickly settled portion of the village.

The new source of supply is a large well about one hundred and fifty feet from Seven Mile River, just above Orr's Pond, — a mill pond at the confluence of Seven Mile River and Four Mile Brook. The well is thirty feet in diameter at the top and twenty-five feet deep. For the first five feet the material removed was a coarse compact gravel of a reddish tint. Beneath this was a stratum from two to six inches in thickness consisting of particles of coarse sand closely cemented together, and having a color somewhat resembling iron rust. Below this stratum to the bottom of the well, twenty-five feet beneath the surface, the material was a coarse sandy gravel in which no quicksand or very fine sand was found, and no stones of a greater diameter than eight inches. At the bottom of the well the material was very coarse.

A tubular well one and one-fourth inches in diameter was driven to a farther depth of twenty-five feet below the bottom of the well, without striking rock.

The walls of the well are of stone for a height of ten feet above the bottom, the first eight feet being laid without mortar. Above the stone work the walls are of brick masonry sixteen inches in thickness for a height of eight feet and twelve inches in thickness for the remaining ten feet, bringing the top of the wall about three

ATTLEBOROUGH.

feet above the surface of the ground. Light is excluded from the well by a wooden roof. A direct connection has been made with Orr's Pond for use in cases of emergency. Water is pumped from the well to the distributing system and to a covered iron tank.

During construction this well is said to have yielded water very freely.

Chemical Examination of Water from the Well of the Attleborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10266	April 17	V. slight, milky.	V. slight.	0.02	4.90	.0000	.0030	.35	.0180	.0000	.0219	1.9	.0065
10386	May 12	None.	None.	0.03	4.60	.0000	.0004	.32	.0280	.0000	.0219	2.2	.0025
10811	Aug. 15	V. slight.	V. slight.	0.01	4.10	.0000	.0006	.31	.0070	.0000	.0316	1.8	.0060
11347	Nov. 17	None.	None.	0.02	4.20	.0000	.0000	.43	.0220	.0001	.0390	1.9	.0140
11473	Dec. 11	None.	None.	0.02	4.35	.0000	.0000	.40	.0300	.0000	.0416	2.2	.0050
Av.	....	....	....	0.02	4.43	.0000	.0008	.36	.0210	.0000	.0312	2.0	.0068

Odor, none.— The samples were collected from a faucet at the pumping station, while pumping.

Microscopical Examination.

No organisms.

Water Supply of Ayer.

Chemical Examination of Water from the Ayer Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10483	June 6	None.	V. slight.	0.00	5.30	.0000	.0008	.36	.0500	.0000	.0547	2.1	.0000
10784	Aug. 12	V. slight.	Slight, earthy.	0.03	5.60	.0004	.0046	.33	.0550	.0002	.0624	2.3	.0280

Odor, none.—— The first sample was collected from the well used as a source of supply for the town; the last sample, from a faucet in the village, and may have consisted wholly or in part of water which had passed through the open distributing reservoir.

Microscopical Examination.

No. 10483. Miscellaneous, *Zoöglœa*, 5.

No. 10784. Diatomaceæ, *Cyclotella*, 4. Algæ, *Scenedesmus*, 1. Fungi, *Crenothrix*, 2. Total, 7.

WATER SUPPLY OF BELMONT.

(See *Watertown.*)

Chemical Examination of Water from Clematis Brook in Belmont.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10085	Mar. 7	V. slight.	V. slight.	1.10	7.90	3.15	.0112	.0296	.0250	.0046	.53	.0350	.0003	1.0764	2.9

Iron, .0190. Odor, none; becoming vegetable on standing or heating. —— The sample was collected from the brook at the point where it flows from a small mill pond known as Kendall's pond. The brook forms the boundary in this vicinity between Belmont and Waltham and is not used as a source of water supply.

Microscopical Examination.

Diatomaceæ, *Meridion*, 1; *Navicula*, 1; *Striatella*, 3. Miscellaneous, *Zoöglœa*, 3. Total, 8.

WATER SUPPLY OF BEVERLY.

(See *Salem.*)

BLACKSTONE.

Chemical Examination of Water from Emerson and Ironstone Brooks and the Upper Ironstone Reservoir, in Uxbridge, and from Angelica Brook in Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
11540	Dec. 22	None.	V. slight.	0.70	3.90	1.65	.0000	.0178	.0160	.0018	.23	.0050	.0000	.7728	0.9
11541	Dec. 22	V. slight.	Cons.	0.12	3.55	1.00	.0004	.0054	.0036	.0018	.21	.0050	.0000	.2352	0.5
11542	Dec. 22	None.	V. slight.	0.60	3.55	1.55	.0008	.0154	.0122	.0032	.25	.0030	.0000	.7014	0.5
11543	Dec. 22	Slight.	V. slight.	0.53	2.40	1.00	.0022	.0260	.0200	.0060	.28	.0070	.0000	.5628	0.6

Odor of all samples, vegetable. —— The samples were collected as follows: — No. 11,540, from Emerson Brook at the saw mill dam in Uxbridge about half a mile above the point where the brook is crossed by the New York and New England Railroad. No. 11,541, from Angelica Brook just above the point where it is crossed by the New York and New England Railroad; this brook is a small stream which enters the Blackstone River from the south just below the village of Millville in Blackstone. No. 11,542, from Ironstone Brook just above the point where it enters the lower Ironstone Reservoir; No. 11,543 from the upper Ironstone Reservoir in the vicinity of the boundary line between Massachusetts and Rhode Island. The samples were collected during an investigation for a water supply for the town of Blackstone.

Microscopical Examination.

The number of organisms per cubic centimeter found in each sample was as follows: No. 11,540, 46; No. 11,541, 24; No. 11,542, 21; No. 11,543, 15.

BOSTON.

WATER SUPPLY OF BOSTON.

The principal change in the conditions affecting the character of the Boston water supply during 1893, is the filtration of the water of Pegan Brook through carefully prepared filter-beds of large area before it is discharged into Lake Cochituate. This brook drains the central portion of the town of Natick, which has no sewerage system.

The extension and increased use of the sewerage systems in Framingham, Marlborough and Westborough, has caused a still greater proportion of the sewage of these towns to be removed from the watershed of the Sudbury River than was the case last year.

The works of the Jamaica Pond Aqueduct Company were purchased by the city of Boston at the end of 1892, and the supply from this source has been permanently discontinued.

SUDBURY RIVER SUPPLY.— *Chemical Examination of Water from Cold Spring Brook, at Head of Reservoir No. 4, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9837	Jan. 2	Distinct, clayey.	Slight.	0.60	2.60	1.25	.0006	.0194	.0164	.0030	.16	.0030	.0000	.6789	0.9
9959	Feb. 1	V. slight.	None.	1.00	5.05	2.00	.0020	.0176	.0152	.0024	.18	.0090	.0000	.8833	1.4
10064	Mar. 1	None.	V. slight.	1.25	4.80	2.25	.0008	.0208	.0196	.0012	.26	.0070	.0000	.9504	1.3
10199	Apr. 3	None.	V. slight.	1.10	3.20	1.65	.0002	.0194	.0176	.0018	.17	.0030	.0001	.7774	1.4
10339	May 1	V. slight.	Slight.	1.35	3.65	1.75	.0004	.0220	.0192	.0028	.24	.0000	.0000	.9125	0.8
10463	June 1	None.	V. slight.	1.80	4.05	2.45	.0000	.0238	.0198	.0040	.26	.0050	.0001	1.1850	1.3
10587	July 5	Slight.	Slight.	1.20	4.35	2.45	.0000	.0302	.0214	.0088	.24	.0000	.0000	.9480	0.9
10717	Aug. 3	V. slight.	V. slight.	0.55	3.70	1.20	.0000	.0208	.0180	.0028	.28	.0030	.0001	.5082	1.1
10952	Sept. 1	V. slight.	V. slight.	2.00	6.10	3.45	.0000	.0392	.0318	.0074	.28	.0000	.0000	1.5958	1.3
11122	Oct. 2	V. slight.	None.	0.85	4.30	1.95	.0000	.0190	.0174	.0016	.29	.0000	.0000	.6468	1.3
11273	Nov. 1	V. slight.	Slight.	2.00	7.90	3.80	.0028	.0424	.0376	.0048	.49	.0070	.0002	1.7040	1.9
11434	Dec. 4	Slight, clayey.	Cons.	1.05	4.50	1.75	.0086	.0228	.0202	.0026	.30	.0000	.0002	.9321	1.4
Av.	....	....	....	1.23	4.52	2.16	.0013	.0248	.0212	.0036	.26	.0031	.0001	.9765	1.3

Averages of Analyses of Previous Years.

-	1889*	-	-	2.24	-	-	.0025	.0410	.0385	.0025	.28	.0056	.0001	-	-
-	1890	-	-	0.91	4.49	2.01	.0011	.0243	.0210	.0033	.24	.0090	.0001	-	1.5
-	1891	-	-	1.30	4.87	2.30	.0009	.0297	.0262	.0035	.23	.0087	.0001	-	1.3
-	1892	-	-	1.44	5.15	2.57	.0003	.0308	.0266	.0042	.25	.0068	.0001	-	1.2
-	1893	-	-	1.23	4.52	2.16	.0013	.0248	.0212	.0036	.26	.0031	.0001	.9765	1.3

* June to December.

NOTE to analyses of 1893; Iron, .0139. Odor, distinctly vegetable.—— The samples were collected from the brook at its entrance into reservoir No. 4.

Microscopical Examination.

Average number of organisms in 1893, 63 per cubic centimeter.

BOSTON.

SUDBURY RIVER SUPPLY.—*Chemical Examination of Water from Reservoir No. 4, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9838	Jan. 2	Slight.	Slight.	0.45	2.65	1.10	.0020	.0154	.0120	.0084	.16	.0000	.0000	.4526	1.3
9960	Feb. 1	V. slight.	V. slight.	0.68	4.15	1.70	.0086	.0276	.0250	.0026	.28	.0050	.0001	.7482	1.3
10065	Mar. 1	V. slight.	V. slight.	0.90	3.90	2.00	.0044	.0198	.0180	.0018	.20	.0150	.0000	.7992	1.1
10200	Apr. 3	V. slight.	V. slight.	0.88	3.65	1.75	.0012	.0178	.0154	.0024	.19	.0100	.0000	.7008	0.9
10340	May 1	V. slight.	Slight.	1.00	3.40	1.35	.0014	.0212	.0188	.0024	.25	.0090	.0002	.7117	0.6
10464	June 1	V. slight.	V. slight.	1.10	3.15	1.85	.0000	.0158	.0132	.0026	.20	.0070	.0001	.8147	0.8
10598	July 5	Slight.	Slight.	0.90	3.35	1.65	.0014	.0256	.0228	.0028	.16	.0000	.0000	.8058	0.9
10718	Aug. 3	Slight.	Slight.	0.70	3.15	1.65	.0002	.0188	.0164	.0024	.26	.0030	.0001	.6031	0.8
10953	Sept. 1	Slight.	Slight.	0.55	3.00	1.35	.0000	.0198	.0130	.0068	.24	.0030	.0000	.6162	0.8
11123	Oct. 2	Distinct.	Cons.	0.70	3.85	1.75	.0000	.0212	.0170	.0042	.24	.0000	.0000	.4697	0.9
11274	Nov. 1	Slight.	Slight.	0.45	3.65	1.25	.0000	.0218	.0158	.0060	.30	.0000	.0001	.5400	0.9
11435	Dec. 4	Slight, clayey.	Cons.	0.95	4.55	2.15	.0090	.0224	.0200	.0024	.30	.0060	.0001	.8658	1.4
Av.	....	....	....	0.77	3.54	1.63	.0024	.0206	.0173	.0033	.23	.0048	.0001	.6773	1.0

Averages of Analyses of Previous Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
-	1887*	-	-	0.74	3.71	1.51	.0005	.0246	-	-	.25	.0033	-	-	-
-	1888	-	-	0.72	3.83	1.70	.0007	.0277	-	-	.22	.0054	.0001	-	-
-	1889	-	-	0.85	3.48	1.98	.0016	.0251	.0218	.0033	.23	.0068	.0002	-	-
-	1890	-	-	0.61	3.67	1.40	.0008	.0222	.0191	.0031	.24	.0096	.0001	-	1.7
-	1891	-	-	0.53	3.24	1.55	.0006	.0187	.0156	.0031	.20	.0062	.0001	-	0.9
-	1892	-	-	0.64	3.60	1.52	.0002	.0200	.0168	.0032	.23	.0061	.0001	-	1.1
-	1893	-	-	0.77	3.54	1.63	.0024	.0206	.0173	.0033	.23	.0048	.0001	.6773	1.0

* June to December.

NOTE to analyses of 1893; Iron, .0118. Odor generally faintly vegetable, sometimes none; on heating the odor is generally somewhat stronger, but rarely unpleasant. The samples were collected from the reservoir near the gate-house one foot beneath the surface. —— The surface of the water in this reservoir was from 18 to 21 feet below high water mark in January and during the next two months rose practically to high water mark, at which point it remained until August. On September first the water had been drawn down 14 feet below high water mark and during the remainder of the year on dates when samples of water were collected for analysis the reservoir never contained more than 9 feet of water and at the first of December was empty. For monthly record of height of water in this reservoir see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 4, Ashland.*

[Number of organisms per cubic centimeter.]

	1893. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	2	2	4	2	2	6	4	2	3	2	6
Number of sample,	9838	9960	10065	10200	10340	10464	10588	10718	10953	11123	11274	11435
PLANTS.												
Diatomaceæ,	31	pr.	pr.	pr.	15	324	141	48	40	9	490	36
Asterionella,	9	pr.	0	0	2	2	0	0	0	0	0	0
Cyclotella,	11	pr.	pr.	pr.	4	126	136	48	38	4	88	7
Diatoma,	0	0	0	0	0	0	0	0	0	0	240	3
Fragilaria,	0	0	0	0	0	15	0	0	0	0	0	0
Synedra,	11	pr.	0	0	7	180	2	0	2	5	160	25
Tabellaria,	0	0	0	0	2	1	3	0	0	0	2	1
Algæ,	3	pr.	0	7	5	18	1	4	120	170	34	0
Chlorococcus,	0	pr.	0	0	0	0	0	1	0	6	4	0
Protococcus,	pr.	0	0	0	0	17	0	0	0	0	8	0
Raphidium,	0	0	0	0	0	0	0	0	120	0	22	0
Scenedesmus,	pr.	0	0	0	0	0	0	0	0	164	0	0
Staurastrum,	3	0	0	0	0	1	1	2	pr.	0	0	0
Zoöspores,	0	pr.	0	7	5	0	0	1	0	0	0	0
Fungi, Crenothrix,	3	0	0	0	pr.	0	0	0	0	8	2	0
ANIMALS.												
Infusoria,	1	5	0	0	1	0	pr.	1	0	4	2	0
Dinobryon cases,	0	0	0	0	0	0	0	0	0	0	2	0
Monas,	0	0	0	0	0	0	pr.	0	0	1	0	0
Peridinium,	1	4	0	0	1	0	0	1	0	3	0	0
Trachelomonas,	pr.	1	0	0	0	0	0	0	0	0	pr.	0
Miscellaneous, Zoöglœa,	36	0	4	0	4	7	3	0	28	260	34	8
TOTAL,	74	5	4	7	25	349	145	53	186	451	562	44

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 4, Ashland, collected near the bottom.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
10011	Feb. 14	Slight.	Slight.	1.00	5.15	2.15	.0042	.0206	.0190	.0016	.32	.0180	.0000	.8235	2.0
10954	Sept. 1	V. slight.	V. slight.	0.72	3.15	1.40	.0006	.0168	.0134	.0034	.24	.0070	.0000	.6478	0.9

Iron, .0130. Odor, vegetable, becoming disagreeable on heating. —— The samples were collected from the reservoir near the bottom. On the dates when the samples were collected the reservoir was only about half full.

Microscopical Examination.

No. 10,011. Diatomaceæ, *Cyclotella*, 8; *Synedra*, 2. Miscellaneous, *Zoöglœa*, 28. Total, 38.

No. 10,954. Diatomaceæ, *Cyclotella*, 32; *Synedra*, 5; *Tabellaria*, 2. Algæ, *Raphidium*, 8. Fungi, *Crenothrix*, 7. Rhizopoda, *Actinophrys*, 1. Vermes, *Anurea*, 1; *Polyarthra*, 1. Miscellaneous, *Zoöglœa*, 24. Total, 81.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Sudbury River at the Upper End of Reservoir No. 2, Ashland.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9839	Jan. 2	Decided.	Cons.	1.00	5.20	2.25	.0008	.0278	.0180	.0098	.28	.0070	.0000	.9490	1.7
9961	Feb. 1	V. slight.	Cons.	1.10	5.45	2.25	.0064	.0200	.0166	.0034	.34	.0100	.0000	.9271	1.4
10066	Mar. 1	Slight.	Cons.	1.20	4.75	2.05	.0052	.0214	.0196	.0018	.32	.0050	.0000	.9072	1.6
10201	Apr. 3	V. slight.	V. slight.	0.85	3.15	1.05	.0000	.0148	.0116	.0032	.19	.0000	.0000	.6789	0.9
10341	May 1	Slight.	Slight.	1.28	3.40	1.55	.0006	.0196	.0176	.0020	.26	.0050	.0001	.8249	0.8
10465	June 1	Slight.	Slight.	1.50	4.10	2.10	.0012	.0258	.0240	.0018	.28	.0120	.0002	1.0612	1.1
10589	July 5	Slight.	Slight.	1.10	4.60	2.15	.0042	.0286	.0236	.0050	.30	.0090	.0001	.7636	1.4
10719	Aug. 3	Slight.	Slight.	0.65	4.85	1.95	.0010	.0228	.0204	.0024	.37	.0070	.0001	.5624	1.3
10955	Sept. 1	Distinct.	Slight.	0.65	3.65	2.20	.0018	.0234	.0192	.0042	.26	.0000	.0000	.6794	1.0
11124	Oct. 2	Slight.	Slight.	0.50	5.25	2.10	.0012	.0188	.0162	.0026	.57	.0200	.0001	.4389	2.1
11275	Nov. 1	Slight.	Slight.	1.20	5.10	2.15	.0000	.0286	.0254	.0032	.45	.0030	.0002	1.0600	1.4
11436	Dec. 4	Slight, clayey.	Cons.	0.90	5.80	2.50	.0000	.0270	.0232	.0038	.42	.0030	.0003	1.0101	1.6
Av.	....	....	....	0.99	4.57	2.03	.0019	.0232	.0196	.0036	.34	.0068	.0001	.8219	1.4

Averages of Analyses of Previous Years.

-	1887*	-	-	1.13	5.37	1.81	.0021	.0313	-	-	.39	.0170	-	-	-
-	1888	-	-	1.19	4.76	2.07	.0018	.0293	-	-	.29	.0108	.0002	-	-
-	1889	-	-	1.25	3.62	1.38	.0013	.0294	.0267	.0027	.30	.0080	.0002	-	-
-	1890	-	-	0.82	5.18	2.09	.0014	.0256	.0220	.0036	.30	.0135	.0001	-	1.7
-	1891	-	-	0.88	4.35	1.81	.0008	.0274	.0236	.0038	.26	.0112	.0001	-	1.1
-	1892	-	-	1.00	4.71	2.08	.0006	.0247	.0214	.0033	.28	.0099	.0001	-	1.3
-	1893	-	-	0.99	4.57	2.03	.0019	.0232	.0196	.0036	.34	.0068	.0001	.8219	1.4

* June to December.

NOTE to analyses of 1893, Iron, .0156. Odor, generally vegetable, occasionally mouldy or unpleasant, becoming somewhat stronger on heating. —— The samples were collected from the river near the old dam at the upper end of Reservoir No. 2, at a depth of one foot beneath the surface.

Microscopical Examination.

Average number of organisms in 1893, 157 per cubic centimeter. The greatest numbers found were 738 in January, consisting chiefly of Zoöglœa and Diatomaceæ, and 282 in November, chiefly Diatomaceæ.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 2, Framingham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9840	Jan. 2	V. slight.	Slight.	1.30	6.10	2.60	.0014	.0234	.0210	.0024	.40	.0050	.0001	1.3067	1.8
9962	Feb. 1	V. slight.	V. slight.	1.15	5.75	2.60	.0046	.0212	.0188	.0024	.31	.0120	.0000	1.0183	1.7
10067	Mar. 1	V. slight.	Cons.	1.00	4.40	1.90	.0010	.0212	.0192	.0020	.32	.0100	.0000	.8496	1.6
10204	Apr. 3	Slight, clayey.	Cons.	0.70	3.20	1.15	.0004	.0146	.0128	.0018	.20	.0120	.0000	.5876	0.8
10342	May 1	Slight.	Slight.	1.25	3.20	1.45	.0010	.0198	.0178	.0020	.26	.0070	.0002	.7665	0.8
10466	June 1	Distinct.	Cons., earthy.	1.30	3.55	1.65	.0004	.0238	.0198	.0040	.25	.0100	.0001	1.0387	0.8
10590	July 5	Slight.	Slight.	1.15	3.95	1.90	.0000	.0260	.0232	.0028	.24	.0030	.0001	.7738	1.1
10720	Aug. 3	Decided.	Cons.	0.80	4.25	2.25	.0000	.0270	.0228	.0042	.30	.0000	.0001	.5994	1.3
10956	Sept. 1	Distinct.	Slight.	0.70	3.85	1.80	.0004	.0202	.0160	.0042	.25	.0000	.0000	.6399	1.1
11125	Oct. 2	Distinct.	Cons.	0.53	3.75	1.50	.0000	.0186	.0150	.0036	.26	.0030	.0000	.5813	1.1
11276	Nov. 1	Slight.	Slight.	0.90	4.05	1.35	.0010	.0238	.0210	.0028	.43	.0030	.0003	.7000	1.1
11437	Dec. 4	Slight, clayey.	V. slight.	0.95	5.30	2.20	.0012	.0234	.0206	.0028	.44	.0000	.0003	.9321	1.6
Av.	....	....	....	0.98	4.28	1.86	.0010	.0219	.0190	.0029	.31	.0054	.0001	.8120	1.2

Averages of Analyses of Previous Years.

-	1887*	-	-	1.09	4.94	1.87	.0015	.0335	-	-	.34	.0048	-	-	-
-	1888	-	-	1.08	4.63	2.01	.0005	.0300	-	-	.30	.0102	.0001	-	-
-	1889	-	-	1.04	3.42	1.26	.0015	.0296	.0252	.0044	.29	.0075	.0002	-	-
-	1890	-	-	0.77	4.58	1.83	.0010	.0235	.0191	.0044	.28	.0128	.0001	-	1.7
-	1891	-	-	0.72	4.02	1.68	.0004	.0230	.0194	.0036	.24	.0105	.0001	-	1.0
-	1892	-	-	0.89	4.35	1.92	.0004	.0231	.0192	.0039	.29	.0082	.0001	-	1.3
-	1893	-	-	0.98	4.28	1.86	.0010	.0219	.0190	.0029	.31	.0054	.0001	.8120	1.2

* June to December.

NOTE to analyses of 1893; Iron, .0139. Odor, generally distinctly vegetable, occasionally unpleasant, becoming somewhat stronger on heating. —— The samples were collected from the reservoir near the gate-house, at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 2, Framingham.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	2	3	4	2	2	6	4	2	3	2	6
Number of sample,	9840	9962	10067	10204	10342	10466	10590	10720	10956	11125	11276	11437
PLANTS.												
Diatomaceæ,	1	4	3	9	275	28	81	443	32	5	121	29
Cyclotella,	0	0	pr.	1	pr.	16	80	360	30	0	36	1
Diatoma,	0	0	0	0	0	pr.	0	2	2	0	44	0
Melosira,	0	0	0	0	9	3	0	17	0	2	1	0
Navicula,	0	0	0	3	3	1	0	0	0	2	0	4
Synedra,	1	1	3	3	252	4	1	60	pr.	1	34	20
Tabellaria,	0	3	0	2	11	4	0	4	0	0	6	4
Cyanophyceæ,	0	0	0	0	pr.	0	0	48	45	0	0	0
Anabæna,	0	0	0	0	pr.	0	0	28	25	0	0	0
Anabæna spores,	0	0	0	0	0	0	0	0	20	0	0	0
Microcystis,	0	0	0	0	pr.	0	0	20	0	0	0	0
Algæ,	0	0	0	0	3	2	31	295	86	111	4	0
Cosmarium,	0	0	0	0	0	0	0	1	0	35	0	0
Glœocystis,	0	0	0	0	0	0	22	0	0	0	0	0
Protococcus,	0	0	0	0	2	2	6	284	25	0	2	0
Raphidium,	0	0	0	0	0	0	0	5	60	0	2	0
Scenedesmus,	0	0	0	0	0	pr.	2	2	0	76	pr.	0
Staurastrum,	0	0	0	0	1	pr.	1	3	1	0	0	0
Fungi, Crenothrix,	pr.	pr.	5	2	18	pr.	0	64	pr.	0	12	0
ANIMALS.												
Rhizopoda, Actinophrys,	0	0	0	0	pr.	pr.	0	1	0	0	0	1
Infusoria,	pr.	0	0	0	1	18	1	14	0	8	0	1
Monas,	pr.	0	0	0	1	18	0	0	0	1	0	0
Peridinium,	0	0	0	0	0	0	0	0	0	7	0	1
Vorticella,	0	0	0	0	0	0	1	14	0	0	0	0
Vermes,	0	0	0	0	0	0	0	0	pr.	0	3	0
Polyarthra,	0	0	0	0	0	0	0	0	pr.	0	1	0
Rotatorian ova,	0	0	0	0	0	0	0	0	0	0	2	0
Miscellaneous, Zoöglœa,	0	2	28	38	144	22	22	160	28	224	28	40
TOTAL,	1	6	36	49	441	70	135	1,025	191	348	168	71

BOSTON.

SUDBURY RIVER SUPPLY.— *Chemical Examination of Water from Walker's Brook Marlborough.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid Total.	Ammonia. Albuminoid Dissolved.	Ammonia. Albuminoid Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9834	Jan. 2	Decided.	Heavy, gray.	0.70	9.30	2.70	.1280	.0748	.0274	.0474	1.60	.1050	.0060	-	3.9
9969	Feb. 6	Slight.	Cons.	0.50	14.05	3.40	.0520	.0216	.0188	.0028	1.96	.3000	.0013	.5037	6.1
10062	Mar. 1	Decided.	Heavy, earthy.	0.60	14.55	4.35	.0716	.0186	.0168	.0018	2.12	.1750	.0020	.6588	6.0
10197	Apr. 3	Slight.	Slight.	0.70	11.65	2.90	.0318	.0200	.0182	.0018	1.59	.3000	.0015	.6095	3.8
10350	May 2	Thick.	Decided.	0.70	17.20	4.90	.0416	.0444	.0314	.0130	1.78	.2000	.0028	.0876	4.1
10475	June 5	Slight.	Cons., brown.	0.50	13.55	4.35	.0044	.0180	.0156	.0024	2.08	.2000	.0015	.4575	5.0
10607	July 5	Distinct.	Slight.	0.05	16.80	5.60	.0030	.0124	.0086	.0038	2.83	.2000	.0018	.1971	5.8
10738	Aug. 7	Slight.	Slight, fibrous.	0.18	15.00	4.25	.0014	.0150	.0126	.0024	1.97	.2000	.0018	.1702	5.3
10964	Sept. 5	Slight.	Slight, brown.	0.05	14.90	3.70	.0000	.0128	.0100	.0028	1.78	.1600	.0002	.1680	6.1
11131	Oct. 2	V. slight.	V. slight.	0.10	11.00	3.20	.0000	.0144	.0120	.0024	1.66	.1000	.0004	.2079	4.3
11272	Nov. 1	Slight, milky.	V. slight.	0.42	18.10	4.20	.0042	.0184	.0160	.0024	2.57	.1440	.0020	.4600	7.7
11432	Dec. 4	Decided.	Cons.	0.07	12.50	3.70	.0664	.0378	.0284	.0094	1.58	.1700	.0024	.7995	4.0
Av.	1893...	....	....	0.38	14.05	3.94	.0337	.0257	.0180	.0077	1.96	.1878	.0020	.3927	5.2
Av.	1892...	....	....	0.49	16.84	4.35	.0307	.0274	.0225	.0048	2.58	.2975	.0037	-	5.7

Iron, .0278. Odor, generally distinctly mouldy or musty, occasionally offensive. On heating, the odor becomes somewhat stronger.——The samples were collected from the brook at the first road bridge below Maple Street, about a mile south of the centre of the city of Marlborough.

This series of analyses is being made in order to determine to what extent the pollution of the brook will be diminished by the introduction of a sewerage system into the city of Marlborough. The system was put in operation in the latter part of 1891.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Stony Brook, at Upper End of Reservoir No. 3, Southborough.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9841	Jan. 2	Decided.	Cons.	0.90	6.20	2.40	.0010	.0344	.0274	.0070	.40	.0100	.0003	1.1023	2.3
9963	Feb. 1	V. slight.	V. slight.	0.90	7.15	2.40	.0116	.0186	.0162	.0024	.52	.0350	.0002	.8030	2.6
10066	Mar. 1	V. slight.	V. slight.	1.20	6.05	2.50	.0084	.0228	.0198	.0030	.46	.0300	.0001	.8928	2.2
10203	Apr. 3	Slight.	Slight.	1.00	4.10	1.35	.0005	.0220	.0196	.0024	.24	.0100	.0002	.7957	0.9
10343	May 1	V. slight.	Slight.	1.30	4.90	2.20	.0012	.0296	.0236	.0060	.39	.0200	.0002	.9818	1.4
10467	June 1	Distinct.	Cons., earthy.	1.70	5.20	2.70	.0018	.0320	.0294	.0026	.34	.0120	.0001	1.1862	1.4
10591	July 5	V. slight.	V. slight.	1.30	5.65	2.60	.0034	.0356	.0334	.0022	.33	.0070	.0000	1.0191	1.8
10721	Aug. 3	V. slight.	Slight.	0.55	5.70	2.15	.0016	.0252	.0210	.0042	.58	.0030	.0001	.4440	1.9
10857	Sept. 1	V. slight.	V. slight.	0.50	5.90	2.20	.0014	.0256	.0208	.0048	.51	.0030	.0001	.5490	2.1
11126	Oct. 2	V. slight.	Slight.	0.38	5.95	1.70	.0000	.0208	.0184	.0024	.71	.0000	.0000	.8850	2.2
11277	Nov. 1	Slight.	V. slight.	0.95	8.10	2.70	.0012	.0368	.0330	.0038	.80	.0070	.0004	.9880	2.3
11438	Dec. 4	V. slight.	V. slight.	0.70	7.40	2.30	.0008	.0246	.0224	.0022	.66	.0150	.0003	.8073	2.6
Av.	....	....	....	0.95	6.03	2.27	.0027	.0273	.0237	.0036	.50	.0127	.0002	.8254	2.0

Averages of Analyses of Previous Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
-	1887*	-	-	0.97	7.74	2.36	.0029	.0365	-	-	.74	.0152	-	-	-
-	1888	-	-	1.16	6.25	2.17	.0039	.0312	-	-	.51	.0303	.0004	-	-
-	1889	-	-	1.11	5.04	1.76	.0061	.0308	.0280	.0028	.50	.0275	.0005	-	-
-	1890	-	-	0.72	7.31	2.12	.0033	.0257	.0225	.0032	.56	.0262	.0003	-	2.4
-	1891	-	-	0.86	6.15	2.24	.0047	.0291	.0256	.0035	.59	.0226	.0003	-	2.0
-	1892	-	-	0.96	6.19	2.35	.0015	.0291	.0252	.0039	.49	.0202	.0002	-	1.9
-	1893	-	-	0.95	6.03	2.27	.0027	.0273	.0237	.0036	.50	.0127	.0002	.8254	2.0

* June to December.

NOTE to analyses of 1893; Iron, .0172. Odor, generally distinctly vegetable, frequently mouldy or unpleasant; on heating, the odor is stronger and frequently grassy. —— The samples were collected from the brook about 50 feet below the first road above Reservoir No. 3, at a depth of one foot beneath the surface.

Microscopical Examination.

Average number of organisms in 1893, 123 per cubic centimeter. In September, when the organisms were most abundant, 302 were found, nearly all of which were *Crenothrix*.

BOSTON.

SUDBURY RIVER SUPPLY. — *Chemical Examination of Water from Reservoir No. 3, Framingham.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9842	Jan. 2	Slight.	Slight.	1.00	6.40	2.80	.0024	.0242	.0220	.0022	.49	.0050	.0001	.9271	2.2
9964	Feb. 1	Slight.	Slight.	0.90	6.15	2.15	.0084	.0240	.0192	.0048	.50	.0200	.0001	.8796	2.2
10069	Mar. 1	V. slight.	Cons.	0.90	4.20	1.85	.0182	.0228	.0204	.0024	.29	.0200	.0001	.7920	1.7
10202	Apr. 3	Distinct, clayey.	Cons.	0.65	3.95	1.30	.0056	.0184	.0140	.0044	.20	.0280	.0001	.6095	1.4
10344	May 1	Slight.	Slight.	1.00	4.00	1.95	.0008	.0206	.0168	.0038	.32	.0200	.0002	.7409	1.3
10468	June 1	Distinct.	Cons.	1.20	4.40	1.90	.0004	.0266	.0244	.0022	.30	.0090	.0002	.9525	1.4
10592	July 5	Distinct.	Slight.	1.20	5.00	2.05	.0000	.0274	.0246	.0028	.26	.0050	.0001	.9243	1.3
10722	Aug. 3	Decided, green.	Cons., brown.	0.85	4.95	2.40	.0000	.0284	.0204	.0080	.36	.0050	.0000	.6660	1.9
10958	Sept. 1	Decided.	Slight.	0.85	4.25	1.80	.0000	.0296	.0214	.0082	.33	.0000	.0000	.7189	1.8
11127	Oct. 2	Decided.	Cons.	0.70	5.25	2.75	.0004	.0346	.0232	.0114	.37	.0000	.0000	.6314	1.6
11278	Nov. 1	Distinct.	Cons.	0.90	5.30	2.25	.0012	.0308	.0212	.0096	.49	.0030	.0004	.7320	1.8
11439	Dec. 4	Slight, clayey.	Slight.	0.65	5.80	2.05	.0014	.0232	.0202	.0030	.57	.0050	.0001	.6435	2.2
Av.	....	....	....	0.90	4.97	2.10	.0028	.0259	.0207	.0052	.37	.0100	.0001	.7681	1.7

Average of Analyses of Previous Years.

-	1887*	-	-	0.91	5.48	2.02	.0073	.0318	-	-	.48	.0170	-	-	-
-	1888	-	-	0.98	4.98	1.79	.0038	.0288	-	-	.40	.0218	.0003	-	-
-	1889	-	-	0.84	4.39	1.50	.0042	.0306	.0254	.0052	.42	.0182	.0003	-	-
-	1890	-	-	0.62	5.40	1.84	.0020	.0238	.0197	.0041	.40	.0229	.0002	-	2.0
-	1891	-	-	0.60	4.75	1.66	.0032	.0242	.0200	.0042	.38	.0190	.0002	-	1.7
-	1892	-	-	0.72	5.17	1.97	.0024	.0254	.0219	.0035	.40	.0211	.0001	-	1.8
-	1893	-	-	0.90	4.97	2.10	.0028	.0259	.0207	.0052	.37	.0100	.0001	.7681	1.7

* June to December.

NOTE to analyses of 1893; Iron, .0178. Odor, generally distinctly vegetable. On heating the odor is stronger and frequently unpleasant or disagreeable.—— The samples were collected from the reservoir near the gate-house at a depth of eight feet beneath the surface. For monthly record of height of water in this reservoir see table at end of Boston analyses.

BOSTON.

SUDBURY RIVER SUPPLY. — *Microscopical Examination of Water from Reservoir No. 3, Framingham.*

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	2	3	4	2	2	6	4	2	3	2	6
Number of sample,	9642	9964	10069	10202	10344	10468	10592	10722	10958	11127	11278	11439
PLANTS.												
Diatomaceæ,	630	pr.	24	13	623	278	51	818	37	1,516	957	212
Asterionella,	35	0	pr.	1	450	60	0	0	15	672	480	100
Cyclotella,	0	pr.	0	0	1	2	48	800	1	0	44	2
Diatoma,	0	pr.	0	0	10	4	0	8	0	0	56	0
Fragilaria,	0	0	0	0	10	6	0	0	0	0	0	0
Melosira,	1	0	0	2	4	28	0	8	0	0	25	18
Synedra,	2	0	2	4	116	74	2	8	1	0	280	80
Tabellaria,	592	0	22	6	32	104	1	9	20	844	72	12
Cyanophyceæ,	0	0	0	0	0	0	17	74	50	0	4	0
Anabæna,	0	0	0	0	0	0	17	52	0	0	0	0
Clathrocystis,	0	0	0	0	0	0	0	22	50	0	4	0
Algæ,	3	0	0	0	103	6	71	24	1	18	37	1
Chlorococcus,	0	0	0	0	1	0	0	5	0	17	1	0
Protococcus,	0	0	0	0	0	5	64	15	0	0	20	0
Raphidium,	1	0	0	0	0	0	0	2	0	0	8	0
Scenedesmus,	2	0	0	0	80	1	3	0	0	0	5	1
Staurastrum,	0	0	0	0	22	0	0	2	1	1	0	0
Staurogenia,	0	0	0	0	0	0	4	0	0	0	3	0
Fungi, Crenothrix,	0	0	0	2	0	0	1	0	0	0	3	0
ANIMALS.												
Infusoria,	1	0	6	2	3	2	2	25	1	125	109	1
Dinobryon,	0	0	5	0	3	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	2	0	0	0	0	0	0	104	1
Monas,	0	0	0	0	0	1	2	2	pr.	0	0	0
Peridinium,	pr.	0	0	0	0	0	0	0	0	124	0	0
Synura,	0	0	0	0	0	0	0	2	0	0	0	0
Trachelomonas,	1	0	1	0	0	1	0	4	1	1	5	0
Vorticella,	0	0	0	0	0	0	0	17	0	0	0	0
Vermes, Polyarthra,	0	0	0	0	0	0	0	0	0	0	7	0
Miscellaneous, Zoöglœa,	82	0	82	64	396	44	2	320	24	432	56	6
TOTAL,	716	pr.	112	81	1,125	330	144	1,261	113	2,091	1,173	220

BOSTON.

COCHITUATE SUPPLY. — *Chemical Examination of Water from Lake Cochituate, in Wayland.*

[Parts per 100,000.]

Averages of Analyses of Previous Years.

-	1887*	-	-	0.21	5.08	1.58	.0017	.0186	-	-	.44	.0006	-	-	-
-	1888	-	-	0.19	4.90	1.24	.0033	.0217	-	-	[illegible]	.0127	.0003	-	-
-	1889	-	-	0.33	5.08	1.62	.0025	.0210	.0177	.0033	.46	.0208	.0003	-	-
-	1890	-	-	0.21	4.74	1.03	.0016	.0184	.0149	.0035	.49	.0206	.0003	-	[illegible]
-	1891	-	-	0.24	4.66	1.44	.0017	.0182	.0146	.0037	[illegible]	.0212	.0002	-	1.9
-	1892	-	-	0.15	4.61	1.35	.0018	[illegible]	[illegible]	.0035	[illegible]	.0152	.0001	-	2.0
-	1893	-	-	0.21	4.64	[illegible]	.0015	.0168	.0138	.0030	[illegible]	.0098	.0002	.3925	2.0

* June to December.

NOTE to analyses of 1893; Iron, .0075. Odor, generally vegetable, frequently unpleasant, sometimes none. — The samples were collected in the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

COCHITUATE SUPPLY. — *Microscopical Examination of Water from Lake Cochituate, in Wayland.*

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	2	3	4	2	2	6	4	2	3	2	6
Number of sample,	9843	9965	10070	10205	10345	10469	10593	10723	10959	11128	11279	11440
PLANTS.												
Diatomaceæ,	**807**	**50**	**34**	**131**	**1,274**	**1,427**	**202**	**0**	**37**	**44**	**192**	**948**
Asterionella,	518	17	4	32	594	570	0	0	22	24	41	172
Cyclotella,	92	22	11	26	74	560	0	0	1	0	17	48
Fragilaria,	0	0	0	0	13	0	0	0	0	16	20	0
Melosira,	180	11	18	72	494	10	0	0	0	4	18	280
Stephanodiscus,	8	0	0	0	0	0	6	0	0	0	0	7
Synedra,	0	0	1	1	98	11	0	0	9	0	0	1
Tabellaria,	9	0	0	pr.	1	276	196	0	5	0	96	440
Cyanophyceæ,	**106**	**0**	**0**	**0**	**0**	**23**	**23**	**2**	**21**	**0**	**60**	**0**
Anabæna,	106	0	0	0	0	20	21	0	3	0	22	0
Clathrocystis,	pr.	0	0	0	0	3	2	0	6	0	pr.	0
Microcystis,	0	0	0	0	0	0	0	2	12	0	38	0
Algæ,	**18**	**0**	**4**	**0**	**0**	**26**	**64**	**24**	**10**	**52**	**76**	**30**
Chlorococcus,	2	0	0	0	0	7	0	0	2	52	0	0
Hyalotheca,	12	0	4	0	0	0	0	0	0	0	0	0
Protococcus,	4	0	0	0	0	19	64	20	6	0	76	30
Staurogenia,	0	0	0	0	0	0	0	4	2	0	0	0
Fungi, Crenothrix,	**0**	**0**	**pr.**	**1**	**0**	**0**	**0**	**0**	**0**	**3**	**pr.**	**1**
ANIMALS.												
Rhizopoda, Actinophrys,	**2**	**pr.**	**1**	**pr.**	**1**	**1**	**1**	**1**	**pr.**	**0**	**1**	**0**
Infusoria,	**3**	**6**	**3**	**pr.**	**24**	**85**	**2**	**0**	**0**	**2**	**70**	**6**
Dinobryon,	0	0	0	0	5	42	0	0	0	0	0	0
Dinobryon cases,	0	0	2	0	7	42	0	0	0	0	70	6
Peridinium,	1	2	0	0	4	0	0	0	0	2	pr.	0
Synura,	0	0	0	0	0	0	2	0	0	0	0	0
Trachelomonas,	2	4	1	pr.	2	1	pr.	0	0	0	0	0
Vorticella,	0	0	0	0	6	0	0	0	0	0	0	0
Crustacea, Cyclops,	**.04**	**.04**	**0**	**0**	**.02**	**.02**	**0**	**0**	**0**	**0**	**0**	**0**
Miscellaneous,	**88**	**2**	**7**	**168**	**508**	**.05**	**7**	**4**	**24**	**88**	**0**	**60**
Acarina,	0	0	0	0	0	.05	0	0	0	.02	0	0
Zoöglœa,	88	2	7	168	508	0	7	4	24	88	0	60
TOTAL,	1,024	58	49	300	1,807	1,562	299	31	92	189	399	1,045

BOSTON.

COCHITUATE WORKS. — *Chemical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9844	Jan. 3	Slight.	Slight.	1.10	5.90	2.35	.0020	.0202	.0160	.0042	.46	.0120	.0000	.9709	2.1
9966	Feb. 2	V. slight.	V. slight.	0.90	5.65	2.20	.0036	.0204	.0182	.0022	.45	.0120	.0001	.8687	2.5
10071	Mar. 2	V. slight.	Slight.	0.65	4.85	1.90	.0022	.0156	.0140	.0016	.42	.0250	.0001	.6480	2.1
10207	Apr. 4	Slight.	Slight.	0.50	4.35	1.40	.0014	.0122	.0106	.0016	.29	.0300	.0001	.4708	1.8
10346	May 1	Slight.	Slight.	0.50	4.20	1.90	.0004	.0164	.0122	.0042	.34	.0250	.0002	.5402	1.3
10470	June 2	Slight.	Slight.	0.60	4.50	1.60	.0000	.0140	.0106	.0034	.36	.0180	.0000	.5175	1.8
10594	July 5	Slight.	Slight.	0.60	4.05	1.85	.0014	.0210	.0186	.0024	.32	.0180	.0000	.5475	1.3
10724	Aug. 3	Slight.	Slight.	0.52	4.45	2.25	.0002	.0202	.0168	.0034	.38	.0100	.0001	.4699	1.6
10960	Sept. 2	Slight.	Slight.	0.55	4.00	1.75	.0000	.0150	.0130	.0020	.34	.0070	.0000	.5609	1.4
11129	Oct. 2	Slight.	Cons.	0.42	3.95	1.50	.0000	.0192	.0156	.0036	.35	.0050	.0000	.4466	1.9
11280	Nov. 1	Slight.	Slight.	0.40	3.95	1.50	.0000	.0164	.0142	.0022	.41	.0030	.0004	.5880	1.6
11441	Dec. 4	V. slight.	V. slight.	0.55	4.65	1.90	.0004	.0174	.0162	.0012	.44	.0060	.0000	.5421	1.7
Av.	....	....	....	0.61	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.5976	1.8

Averages of Analyses of Previous Years.

-	1887*	-	-	0.35	4.89	1.37	.0002	.0225	-	-	.41	.0094	-	-	-
-	1888	-	-	0.38	4.94	1.53	.0012	.0215	-	-	.40	.0183	.0002	-	-
-	1889	-	-	0.51	4.71	1.43	.0005	.0199	.0176	.0023	.42	.0272	.0002	-	-
-	1890	-	-	0.35	4.70	1.25	.0003	.0169	.0148	.0021	.42	.0241	.0001	-	2.2
-	1891	-	-	0.37	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	-	1.7
-	1892	-	-	0.37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	-	1.9
-	1893	-	-	0.61	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.5976	1.8

* June to December.

NOTE to analyses of 1893; Iron, .0121. Odor, faintly vegetable, sometimes none. The odor becomes somewhat stronger on heating and occasionally unpleasant.

The table of averages shows that the water supplied to the city in 1893 had a higher color than in previous years, a result which is due to a combination of several circumstances.

The color of the water of streams varies from year to year and during 1893 was above the average. It is also the case that at the end of 1892 the reservoirs were filled with an unusually dark colored water, owing to heavy rains in November.

The water of Sudbury River has a higher color than that of Lake Cochituate, and the increasing consumption of water, which requires a larger proportion to be furnished from the river each year, tends to increase the color of the water supplied to the city.

There is still another cause for the darker color of the water in 1893, namely, that all the water supplied to Chestnut Hill Reservoir from Dec. 10, 1892, to Jan. 10, 1893, came from Sudbury River, owing to the temporary disuse of the Cochituate aqueduct while a sewer was being constructed beneath it in Newton.

BOSTON.

COCHITUATE WORKS. — *Microscopical Examination of Water from a Faucet at the Massachusetts Institute of Technology, Boston.*

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	3	2	3	4	2	2	6	4	5	3	2	6
Number of sample,	9844	9966	10071	10207	10346	10470	10594	10724	10960	11129	11280	11441
PLANTS.												
Diatomaceæ,	226	11	10	18	435	80	158	237	140	208	347	117
Asterionella,	44	4	2	4	246	22	0	0	8	35	60	36
Cyclotella,	pr.	7	1	2	9	16	26	4	4	0	16	7
Fragilaria,	0	0	0	0	0	23	0	0	0	15	5	0
Melosira,	4	0	4	6	90	2	0	0	0	10	6	0
Synedra,	0	pr.	1	2	58	2	0	1	0	0	0	2
Tabellaria,	178	0	2	4	82	15	132	232	128	148	260	72
Cyanophyceæ,	0	0	0	0	0	0	1	7	1	0	15	0
Clathrocystis,	0	0	0	0	0	0	1	6	0	0	3	0
Microcystis,	0	0	0	0	0	0	0	1	1	0	12	0
Algæ,	0	0	pr.	0	1	10	0	5	23	7	9	0
Chlorococcus,	0	0	0	0	1	pr.	0	0	5	0	0	0
Protococcus,	0	0	0	0	0	10	0	5	5	0	5	0
Raphidium,	0	0	0	0	0	0	0	0	16	0	4	0
Scenedesmus,	0	0	pr.	0	0	pr.	0	0	0	7	0	0
ANIMALS.												
Rhizopoda, Difflugia,	0	0	0	0	0	0	0	0	0	2	0	0
Infusoria,	pr.	8	2	0	1	0	0	0	5	6	0	0
Dinobryon cases,	0	0	1	0	0	0	0	0	4	0	0	0
Peridinium,	pr.	8	0	0	pr.	0	0	0	0	5	0	0
Trachelomonas,	0	pr.	1	0	1	0	0	0	1	1	0	0
Miscellaneous, Zoöglœa,	4	0	30	3	20	16	12	36	28	64	5	11
TOTAL,	230	19	42	21	457	106	171	285	200	307	376	128

BOSTON.

MYSTIC SUPPLY.— *Chemical Examination of Water from Mystic Lake.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9847	Jan. 4	Slight, brown.	Slight, brown.	0.04	13.80	1.65	.0456	.0180	.0152	.0028	2.80	.0700	.0012	.2044	5.3
9971	Feb. 6	V. slight.	Slight.	0.08	14.50	2.00	.0520	.0234	.0206	.0028	2.90	.0800	.0002	.2066	5.4
10061	Mar. 1	Slight.	Slight.	0.10	12.50	2.80	.0352	.0222	.0188	.0034	2.20	.0900	.0005	.2866	4.6
10198	Apr. 3	Distinct, clayey.	Slight.	0.20	8.30	1.30	.0420	.0252	.0206	.0046	1.80	.0600	.0006	.4015	2.9
10347	May 2	Distinct, brown.	Cons., brown.	0.08	11.05	2.15	.0480	.0176	.0102	.0074	1.98	.0350	.0005	.2847	3.8
10476	June 5	Distinct, green.	Slight, green.	0.20	10.10	2.35	.0146	.0222	.0176	.0046	1.92	.0900	.0010	.3525	3.4
10586	July 5	Distinct.	Cons., green.	0.05	11.75	2.50	.0020	.0190	.0140	.0050	2.36	.0750	.0020	.2449	3.6
10731	Aug. 4	Distinct.	Cons.	0.10	12.50	2.25	.0008	.0294	.0168	.0126	2.66	.0200	.0001	.2627	4.2
10944	Sept. 1	Distinct.	Slight.	0.12	12.60	1.60	.0004	.0216	.0142	.0074	2.68	.0800	.0001	.2449	4.2
11121	Oct. 1	V. slight.	Slight, green.	0.10	15.50	2.50	.0006	.0196	.0146	.0050	3.19	.0300	.0006	.2156	4.9
11282	Nov. 1	Distinct.	Slight.	0.05	14.75	2.40	.0196	.0210	.0144	.0066	3.12	.0400	.0016	.2760	5.0
11431	Dec. 4	V. slight.	V. slight.	0.03	14.05	2.55	.0274	.0182	.0136	.0046	2.77	.0800	.0005	.2067	5.3
Av.	....	....	....	0.10	12.62	2.17	.0240	.0215	.0159	.0056	2.49	.0583	.0007	.2656	4.4

Averages of Analyses of Previous Years.

-	1887*	-	-	0.28	10.82	1.62	.0114	.0266	-	-	2.06	.0263	-	-	-
-	1888	-	-	0.21	10.12	1.76	.0244	.0267	-	-	1.94	.0433	.0016	-	-
-	1889	-	-	0.26	9.02	1.97	.0211	.0278	.0209	.0069	1.67	.0586	.0012	-	-
-	1890	-	-	0.18	10.65	1.78	.0197	.0223	.0183	.0040	1.57	.0796	.0008	-	3.7
-	1891	-	-	0.13	9.50	1.81	.0186	.0242	.0187	.0055	1.58	.0731	.0012	-	3.5
-	1892	-	-	0.07	11.52	2.09	.0185	.0206	.0153	.0053	2.22	.0698	.0007	-	4.1
-	1893	-	-	0.10	12.62	2.17	.0240	.0215	.0159	.0056	2.49	.0583	.0007	-	4.4

* June to December.

NOTE to analyses of 1893; Iron, .0040. Odor, generally vegetable and mouldy or disagreeable.—— The samples were collected from the lake near the gate-house. For monthly record of height of water in this lake, see table at end of Boston analyses.

BOSTON.

MYSTIC SUPPLY. — *Microscopical Examination of Water from Mystic Lake.*

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	5	7	2	4	2	6	5	5	2	2	8	4
Number of sample, . .	9847	9971	10061	10198	10347	10476	10586	10731	10944	11121	11282	11431
PLANTS.												
Diatomaceæ, . .	345	18	19	3	524	3,972	5,647	1,064	971	409	7,841	2,406
Asterionella, . .	98	6	11	pr.	25	0	0	0	0	0	1	0
Diatoma, . . .	102	0	0	0	0	0	7	0	0	0	0	0
Fragilaria, . . .	66	0	8	0	47	92	160	164	9	464	640	6
Melosira, . . .	0	0	0	1	22	0	0	0	0	8	0	0
Navicula, . . .	8	0	1	0	0	0	0	0	0	1	0	0
Synedra, . . .	76	12	4	2	402	3,880	5,480	900	960	81	7,200	2,400
Tabellaria, . . .	0	0	0	0	28	0	0	0	2	0	0	0
Algæ, ...	124	2	2	0	26	197	183	1,487	137	264	980	164
Cosmarium, . .	5	1	0	0	0	0	0	32	2	pr.	28	4
Pediastrum, . .	0	0	0	0	0	pr.	1	3	7	0	2	0
Protococcus, . .	0	0	pr.	0	26	28	0	44	0	0	220	9
Raphidium, . .	5	0	0	0	0	pr.	0	0	0	0	0	2
Scenedesmus, . .	114	1	2	0	0	164	180	1,360	128	264	680	148
Staurastrum, . .	pr.	0	0	0	0	5	2	48	0	0	0	1
Fungi, Crenothrix, .	1	0	pr.	0	pr.	0	0	0	0	0	20	40
ANIMALS.												
Rhizopoda, Difflugia, .	0	0	0	0	3	0	0	0	0	0	0	0
Infusoria, Peridinium,	pr.	0	pr.	0	0	0	272	2,100	0	228	15	0
Vermes, ...	0	0	0	0	1	0	1	3	1	0	0	0
Anuræa, . . .	0	0	0	0	0	0	0	1	1	0	0	0
Monocerca, . . .	0	0	0	0	1	0	1	0	0	0	0	0
Polyarthra, . . .	0	0	0	0	0	0	0	2	0	0	0	0
Miscellaneous, Zoöglœa, .	280	0	244	160	5	36	3	3	760	36	76	8
Total, ...	750	20	265	163	559	4,205	6,106	4,657	1,869	1,027	8,882	2,618

BOSTON.

MYSTIC SUPPLY.—*Chemical Examination of Water from Mystic Lake, at Various Depths.*

[Parts per 100,000.]

Iron, in the first sample, .0080; in the second, none; in the third, .0020; in the last, .0770.

Odor of the first sample, faintly disagreeable, becoming stronger on heating; of the next two samples, very faint or none; of the last sample, offensive.——The first sample was collected at the surface, and the others in order at depths of 20, 54 and 74 feet respectively beneath the surface.

MYSTIC SUPPLY.—*Microscopical Examination of Water from Mystic Lake, at Various Depths.*

[Number of organisms per cubic centimeter.]

	[illegible]			
	March.	March.	March.	March.
Day of examination,	9	9	9	9
Number of sample,	10095	10096	10097	10098
PLANTS.				
Diatomaceæ,	0	52	72	98
Asterionella,	0	38	60	92
Diatoma,	0	0	4	2
Fragilaria,	0	0	1	0
Navicula,	0	pr.	2	1
Synedra,	0	14	5	3
Algæ,	0	[illegible]	pr.	7
Protococcus,	0	0	0	4
Scenedesmus,	0	0	pr.	2
Ulothrix,	0	0	0	1
Miscellaneous, Zoöglœa,	158	175	320	2,028
TOTAL,	158	228	392	2,133

BOSTON.

MYSTIC SUPPLY. — *Chemical Examination of Water from a Faucet in Everett supplied from the Mystic Works.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
10101	1893. Mar. 7	Slight.	Slight.	0.18	13.20	2.50	.0672	.0232	.0212	.0020	2.64	.0900	.0002	.3024	5.0

Iron, .0100. Odor, offensive.——The sample was collected from a faucet in Everett.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 16; *Synedra*, 1. Fungi, *Fungus*, 8. Infusoria, *Vorticella*, 1. Miscellaneous, *Zoöglœa*, 208. Total, 234.

Table showing the Average Monthly Heights in Feet above Tide-marsh level of the Water in the Lakes and Storage Reservoirs of the Boston Water Works, from which Samples of Water were collected during the Year 1893.

	Reservoir No. 2. Flash Boards, 167.12	Reservoir No. 3. Stone Crest, 175.24	Reservoir No. 4. Flash Boards, 215.21	Farm Pond. High Water, 149.25	Lake Cochituate High Water, 134.36	Mystic Lake. High Water, 7.00
January,	162.95	169.42	195.79	148.78	128.38	4.64
February,	164.17	172.49	201.05	149.08	128.71	4.33
March,	165.02	174.17	210.22	149.06	131.55	4.43
April,	166.20	175.60	214.59	149.42	134.03	6.22
May,	166.43	175.59	214.66	149.75	134.41	6.37
June,	166.96	174.79	215.15	148.87	133.68	6.41
July,	162.92	171.84	215.06	148.69	132.49	4.52
August,	161.29	167.57	208.63	148.55	131.21	2.64
September,	161.86	167.75	190.30	148.42	129.80	1.80
October,	158.99	161.10	180.38	148.27	128.24	—0.96
November,	157.48	158.69	172.70	148.37	128.03	—0.20
December,	156.55	162.90	171.87	148.63	127.67	1.19

The reservoirs on Sudbury River were drawn to an unusually low level in 1893. Reservoir No. 2 in December contained 116,500,000 gallons equal to 22 per cent. of its total capacity; Reservoir No. 3 in November contained 62,000,000 gallons equal to 5.6 per cent. of its total capacity; Reservoir No. 4 in December was practically empty, containing only 11,000,000 gallons, equal to less than one per cent. of its total capacity.

BRADFORD.

WATER SUPPLY OF BRADFORD. — BRADFORD WATER COMPANY.

Chemical Examination of Water from the Wells of the Bradford Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1893.												
9889	Jan. 17	Slight, milky.	Slight, rusty.	0.60	5.80	.0344	.0062	.30	.0800	.0000	.0949	2.1	.1240
10022	Feb. 15	Distinct, rusty.	Cons., rusty.	0.28	5.00	.0302	.0052	.31	.0500	.0001	.1035	2.5	.1000
10103	Mar. 8	Distinct, milky.	None.	0.30	6.10	.0254	.0054	.34	.0600	.0005	.0720	2.7	.0620
10233	Apr. 11	Decided, milky.	Cons., rusty.	0.55	4.70	.0342	.0036	.32	.0650	.0001	.0876	2.2	.0400
10371	May 9	Distinct, milky.	Cons., brown.	0.40	5.40	.0060	.0068	.20	.0100	.0001	-	0.8	.0000
10496	June 7	Slight, milky.	V.slight.	0.12	5.70	.0122	.0036	.33	.1000	.0005	.0469	2.7	.0220
10613	July 6	Distinct, milky.	Cons., rusty.	0.02	6.10	.0298	.0016	.26	.0550	.0001	.0800	2.3	.0657
10753	Aug. 9	Distinct, milky.	Cons., rusty.	0.03	6.00	.0328	.0028	.30	.0700	.0001	.1501	2.5	.0700
11012	Sept. 11	Decided.	Slight, rusty.	0.30	6.70	.0370	.0062	.30	.0100	.0056	.1131	3.5	.0600
11158	Oct. 9	Decided, milky.	Cons., rusty.	0.25	5.80	.0438	.0032	.28	.0880	.0000	.1078	2.1	.1260
11308	Nov. 8	Decided, milky.	Cons.	0.65	6.70	.0334	.0068	.32	.0220	.0020	.1480	3.2	.0730
11453	Dec. 6	Decided, milky.	None.	0.50	5.60	.0370	.0048	.28	.0100	.0008	.0897	2.9	.0960
Av.	....	....	....	0.33	5.80	.0297	.0047	.30	.0475	.0008	.0994	2.5	.0774

Averages of Analyses of Previous Years.

-	1889*	-	-	0.00	3.95	.0000	.0014	.21	.0400	.0000	-	1.6	-
-	1890†	-	-	0.00	5.30	.0002	.0036	.34	.0150	.0001	-	2.6	-
-	1891‡	-	-	0.04	5.40	.0000	.0027	.23	.0350	.0001	-	1.8	-
-	1892	-	-	0.03	6.59	.0262	.0029	.28	.0760	.0003	-	2.4	-
-	1893	-	-	0.33	5.80	.0297	.0047	.30	.0475	.0008	.0994	2.5	.0774

* July. † October. ‡ April, two samples.

NOTE to analyses of 1893; Odor, in February, unpleasant; in May distinctly vegetable and mouldy; at other times none. On heating the odor became distinctly unpleasant in the March sample, faintly earthy in April, and faintly vegetable in June and August.

Nos. 10,103, 10,496, 11,012, 11,308 and 11,453 were collected from a faucet on Grove Street; the remaining samples, from a faucet at the pumping station.

It is probable that the water of these wells, as it comes from the ground, is nearly or quite clear and colorless, but, owing to the oxidation of the iron which it contains, it quickly becomes turbid and colored. The particles of oxide of iron which give the turbidity

to the water are at first so very fine that they communicate to the water a milky appearance which cannot be removed by filtration, and the effect of it is to make the water appear colored as if from dissolved coloring matter. When the oxidation of the iron is complete, a rusty precipitate usually forms and the supernatant or filtered water is again clear and colorless. Any record of turbidity, sediment or color, while the oxidation of the iron is in progress, relates, therefore, to a passing phenomenon, but is nevertheless of interest as showing a condition which the water may assume; these records cannot, however, be considered as indicating the comparative character of the water from month to month, because they depend so largely upon the extent of the oxidation of the iron at the time they were made. The presence of iron affects the determination of the "oxygen consumed," and the results of this determination as given in the tables are in consequence all a little higher than they would otherwise be. A progressive deterioration of this water, as compared with previous years, will be noted. The organic matter, as shown by the albuminoid ammonia, and the product of its decomposition, as shown by the free ammonia, are decidedly on the increase.

Microscopical Examination of Water from the Wells of the Bradford Water Company.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	17	10	12	10	9	8	10	14	10	10	7
Number of sample,	9889	10022	10103	10233	10371	10496	10613	10753	11012	11158	11308	11458
PLANTS.												
Fungi, Crenothrix,	0	0	0	0	0	pr.	0	0	7	1	0	0
ANIMALS.												
Infusoria,	0	0	0	0	0	4	0	1	0	0	0	0
Dinobryon cases,	0	0	0	0	0	4	0	0	0	0	0	0
Peridinium,	0	0	0	0	0	pr.	0	1	0	0	0	0
Miscellaneous, Zoöglœa,	738	1872	328	912	76	58	1000	600	320	208	88	64
TOTAL,	738	1872	328	912	76	62	1000	601	327	209	88	64

BRAINTREE.

Water Supply of Braintree.

Chemical Examination of Water from the Filter-gallery of the Braintree Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9048	Jan. 4	V. slight.	V. slight.	0.00	4.90	.0006	.0090	.85	.0650	.0000	-	2.2	.0000
9976	Feb. 6	None.	None.	0.02	4.90	.0004	.0052	.92	.0500	.0000	.0912	2.3	.0020
10102	Mar. 8	None.	None.	0.08	4.50	.0006	.0056	.83	.0400	.0000	.1692	2.1	.0025
10232	Apr. 11	None.	None.	0.05	4.75	.0000	.0040	.84	.0500	.0000	.1314	1.4	.0030
10374	May 9	None.	None.	0.03	4.45	.0000	.0082	.79	.0500	.0000	.1752	1.3	.0015
10495	June 7	None.	None.	0.02	4.25	.0000	.0052	.86	.0300	.0000	.1314	1.6	.0025
10608	July 6	None.	V. slight.	0.01	4.75	.0006	.0030	.81	.0280	.0000	.0438	1.4	.0000
10752	Aug. 9	Slight, milky.	Slight.	0.05	4.50	.0004	.0044	.76	.0120	.0003	.0607	1.3	.0060
11000	Sept. 11	None.	V. slight.	0.05	4.65	.0000	.0042	.82	.0050	.0002	.0858	1.5	.0075
11157	Oct. 9	None.	V. slight.	0.08	5.10	.0000	.0026	.83	.0180	.0001	.0847	1.8	.0150
11316	Nov. 9	None.	V. slight.	0.00	4.80	.0000	.0036	.84	.0450	.0000	.1040	1.6	.0015
11454	Dec. 6	None.	None.	0.00	5.10	.0000	.0032	.84	.0430	.0000	.0546	2.5	.0025
Av.	....	....	....	0.03	4.72	.0002	.0049	.83	.0363	.0001	.1029	1.8	.0037

Averages of Analyses of Previous Years.

-	1887-88*	-	-	0.07	7.14	.0006	.0045	.85	.0948	.0003	-	-	-
-	1892	-	-	0.02	4.69	.0002	.0030	.75	.0192	.0001	-	1.8	-

* June, 1887, to May, 1888.

Note to analyses of 1893; Odor, of No. 10102, faintly vegetable; of the others, none. On heating a very faintly vegetable odor was developed in No. 10232.—— The samples were collected from a faucet at the pumping station.

Microscopical Examination

No. 9848. Diatomaceæ, *Tabellaria*, 62; Nos. 10495 and 10608, Cyanophyceæ, *Anabæna*, 5 in the first, and one in the last; Nos. 10495 to 11157 inclusive each contained a few *Crenothrix* or *Zoöglœa*. In the remaining samples no organisms were found.

BRAINTREE.

Chemical Examination of Water from Little Pond, Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10399	May 16	V. slight.	Slight.	0.30	3.75	-	.0000	.0190	-	-	.64	.0030	.0001	.4453	0.9
10751	Aug. 9	Slight.	Slight.	0.15	4.10	1.85	.0000	.0178	.0140	.0038	.74	.0000	.0000	.3256	1.3
10999	Sept. 11	Distinct.	Slight.	0.20	4.60	-	.0000	.0228	.0212	.0016	.76	.0000	.0000	.3666	0.9
Av..	....	....	....	0.22	4.15	-	.0000	.0199	-	-	.71	.0010	.0000	.3792	1.0

Iron, .0045. Odor, faintly vegetable, becoming stronger in the last two samples on heating.—The samples were collected from the pond near the filter-gallery of the Braintree water works, which is situated on the shore of the pond. It is said that up to the end of 1893, no water had been drawn directly from the pond for the supply of the town.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: In May, 93, chiefly *Diatomaceæ;* in August, 165, chiefly *Algæ;* in September, 62, chiefly *Algæ* and *Cyanophyceæ.*

Water Supply of Bridgewater and East Bridgewater.— The Bridgewaters Water Co.

In 1892, the works of this company for collecting ground water were again enlarged by sinking five additional six-inch tubular wells in the low ground between the present works and the river. The new wells are located in a line parallel to the river, and are said to range from 100 to 160 feet in depth. Water is pumped from these wells by means of an auxiliary pump into one of the large wells near the pumping station.

BRIDGEWATER AND EAST BRIDGEWATER.

Chemical Examination of Water from the Wells of the Bridgewaters Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10474	June 5	V. slight.	Cons.	0.02	7.00	.0002	.0004	.44	.0050	.0000	.0487	2.6	.0200
10596	July 5	Slight, clayey.	Cons., sand.	0.02	4.35	.0000	.0074	.46	.0400	.0001	.0803	0.6	.0060
10755	Aug. 7	None.	V. slight.	0.10	6.50	.0004	.0014	.41	.0400	.0000	.0908	2.0	.0100
10969	Sept. 5	V. slight.	V. slight.	0.02	6.75	.0000	.0004	.40	.0380	.0000	.0000	2.5	.0185
Av.	....	....	....	0.04	6.15	.0002	.0024	.43	.0308	.0000	.0550	1.9	.0136

Averages of Analyses of Previous Years.

-	1888-89*	-	-	0.02	4.20	.0011	.0016	.47	.0307	.0001	-	-	-

* June, 1888 to June, 1889.

Note to 1893 analyses; Odor, none. The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Wells of the Bridgewaters Water Company.

[Number of organisms per cubic centimeter.]

	1893.			
	June.	July.	August.	September.
Day of examination,	6	6	10	7
Number of sample,	10474	10596	10755	10969
PLANTS.				
Diatomaceæ, Synedra,	pr.	18	0	0
Fungi, Crenothrix,	78	0	5	3
ANIMALS.				
Infusoria, Trachelomonas,	pr.	0	0	1
Miscellaneous, Zoöglœa,	22	3	18	7
Total,	100	21	23	11

BRIDGEWATER AND EAST BRIDGEWATER.

Chemical Examination of Water from the Town River at Bridgewater, opposite the Wells of the Bridgewaters Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
10473	June 5	Slight.	Slight.	2.70	5.70	2.85	.0024	.0292	.0242	.0050	.44	.0090	.0002	1.4487	0.8
10595	July 5	Slight.	Cons.	1.70	5.05	2.30	.0020	.0348	.0312	.0036	.40	.0050	.0000	1.1242	1.1
10754	Aug. 7	Distinct, yellow.	Cons., rusty.	0.80	4.40	2.10	.0048	.0236	.0192	.0044	.54	.0050	.0001	0.6754	1.1
10968	Sept. 5	Slight.	Slight.	2.00	6.75	3.45	.0012	.0406	.0354	.0052	.54	.0050	.0001	1.3960	1.6
Av.	....	....	....	1.80	5.48	2.68	.0026	.0321	.0275	.0046	.48	.0060	.0001	1.1598	1.2

Iron, .0275. Odor, distinctly vegetable, becoming stronger on heating, and sometimes also mouldy. —— The samples were collected from the river opposite the works of the Bridgewaters Water Company.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: In June, 183; in July, 144; in August, 2,651; in September, 83. The numbers consisted almost wholly of *Crenothrix* and *Zoöglœa*.

WATER SUPPLY OF BROCKTON.

Chemical Examination of Water from Salisbury Brook at the Point where it enters the Storage Reservoir of the Brockton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9857	Jan. 9	None.	V. slight.	1.30	7.05	2.90	.0004	.0256	.0236	.0020	.66	.0050	.0004	1.3360	2.1
11296	Nov. 7	None.	V. slight.	1.70	6.55	3.25	.0008	.0312	.0290	.0022	.74	.0000	.0000	1.8160	1.6

Iron, .0110. Odor, distinctly vegetable. —— The samples were collected from the brook just above the reservoir.

Microscopical Examination.

No. 9857. Diatomaceæ, *Epithemia*, 1; *Meridion*, 1. Total, 2.

No. 11296. Diatomaceæ, *Cyclotella*, 1; Miscellaneous *Zoöglœa*, 1. Total, 2.

BROCKTON.

Chemical Examination of Water from Salisbury Brook Storage Reservoir, Brockton.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9658	Jan. 9	Slight.	Slight.	0.60	4.20	1.70	.0008	.0234	.0184	.0050	.48	.0000	.0000	.7600	1.4
9977	Feb. 7	Slight.	Slight, green.	0.65	4.46	2.00	.0008	.0284	.0224	.0060	.50	.0000	.0000	.7811	1.4
10087	Mar. 7	Slight.	V. slight.	0.90	4.00	2.00	.0006	.0184	.0152	.0032	.38	.0000	.0000	.8064	1.4
10213	Apr. 5	Slight.	Cons.	0.70	3.25	1.20	.0028	.0150	.0128	.0022	.37	.0030	.0001	.5183	0.3
10365	May 8	V. slight.	Slight.	0.60	2.95	1.55	.0000	.0154	.0136	.0018	.30	.0030	.0000	.5049	0.6
10481	June 6	Slight.	Cons.	0.80	3.70	1.65	.0006	.0222	.0176	.0046	.36	.0050	.0001	.7738	0.5
10641	July 11	Distinct, green.	Slight, yellow.	0.60	3.40	1.95	.0004	.0262	.0228	.0034	.34	.0090	.0000	.8249	0.5
10745	Aug. 8	Distinct.	Cons.	0.65	3.50	1.90	.0000	.0216	.0162	.0054	.38	.0000	.0000	.5143	0.3
10966	Sept. 5	Distinct.	Slight.	0.60	3.40	1.70	.0016	.0260	.0222	.0038	.36	.0030	.0001	.6480	0.6
11138	Oct. 4	Slight.	Cons., green.	0.60	3.00	1.75	.0000	.0312	.0268	.0044	.40	.0000	.0000	.5775	0.5
11297	Nov. 7	Slight.	Slight.	0.70	3.25	1.30	.0002	.0286	.0228	.0058	.46	.0000	.0001	.6240	0.8
11449	Dec. 5	Slight.	Cons.	0.65	4.00	1.65	.0006	.0276	.0240	.0036	.47	.0000	.0002	.6201	0.5
Av..	....	....	....	0.67	3.59	1.70	.0007	.0237	.0196	.0041	.40	.0019	.0001	.6703	0.7

Averages of Analyses of Previous Years.

-	1887†	-	-	0.99	4.94	2.25	.0033	.0541	-	-	.33	.0069	-	-	-
-	1888	-	-	0.76	3.77	1.61	.0031	.0369	-	-	.31	.0066	.0001	-	-
-	1889	-	-	0.78	2.79	1.01	.0028	.0306	.0218	.0078	.30	.0048	.0002	-	-
-	1890	-	-	0.75	4.07	1.98	.0016	.0274	.0219	.0055	.32	.0063	.0001	-	0.9
-	1891	-	-	0.62	3.15	1.45	.0010	.0213	.0169	.0044	.28	.0061	.0001	-	0.6
-	1892	-	-	0.55	3.41	1.37	.0004	.0213	.0168	.0045	.36	.0030	.0000	-	0.7
-	1893	-	-	0.67	3.59	1.70	.0007	.0237	.0196	.0041	.40	.0019	.0001	.6545	0.7

* In addition to the analyses of water from this reservoir given here, the results of examinations of three samples of water collected from various depths under the ice on March 15, 1893, may be found in the annual report of this Board for 1892, page 340. The additional analyses were made as a part of an investigation to learn the quantity of dissolved oxygen in water under the ice.

† June to December.

NOTE to analyses of 1893; Iron, .0157. Odor generally distinctly vegetable, and very frequently disagreeable. On heating, the odor usually becomes somewhat stronger, and in January and February was very disagreeable. —— The samples were collected from the reservoir near the gate-house at a depth of one foot beneath the surface. For a record of heights of water in this reservoir on dates when samples of water were collected for analysis see page 129.

The table of averages shows that there has been a marked decrease in the amount of albuminoid ammonia in this water since the examinations were begun in 1887, indicating a corresponding improvement in its quality. An examination of the monthly analyses during this time, shows that during the earlier years there was a large fluctuation in the amount of albuminoid ammonia in the different seasons of the year, the greatest quantities being found in the summer and early autumn, when abundant growths of microscopic organisms were present in the water. The decrease in the amount of albuminoid ammonia, as shown in the table of averages, is due chiefly to the decrease in the growths of these organisms in summer.

BROCKTON.

Microscopical Examination of Water from Salisbury Brook Storage Reservoir, Brockton.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	9	8	7	10	7	13	9	6	5	9	7
Number of sample,	9858	9977	10067	10213	10365	10481	10641	10745	10966	11138	11297	11449
PLANTS.												
Diatomaceæ,	1182	2591	146	308	449	98	116	540	2670	3300	311	103
Asterionella,	2	5	0	pr.	23	34	56	21	640	0	4	15
Cyclotella,	0	164	0	1	0	0	2	36	28	0	2	0
Diatoma,	4	0	0	0	pr.	1	5	176	76	9	1	0
Fragilaria,	0	0	0	0	0	0	6	0	0	0	0	0
Melosira,	0	0	0	42	90	33	15	64	244	35	78	0
Navicula,	0	0	0	0	16	0	0	0	1	0	0	0
Synedra,	1172	2422	146	250	280	3	5	7	1	0	26	0
Tabellaria,	4	0	0	15	40	27	27	236	1680	3256	200	88
Cyanophyceæ, Clathrocystis,	0	0	0	0	0	5	0	0	1	0	0	0
Algæ,	1	3	pr.	0	8	45	5	85	17	16	34	2
Pediastrum,	0	0	0	0	0	pr.	1	2	3	1	2	0
Raphidium,	0	0	0	0	0	0	2	0	6	0	5	0
Scenedesmus,	0	0	pr.	0	6	24	0	3	4	15	26	2
Staurastrum,	0	3	0	0	1	18	0	80	4	0	1	0
Zoöspores,	1	0	0	0	1	3	2	0	0	0	pr.	0
ANIMALS.												
Rhizopoda, Difflugia,	0	0	0	0	0	pr.	0	0	0	0	1	0
Infusoria,	3	4	4	2	10	5	49	8	6	3	2	5
Cryptomonas,	0	3	0	pr.	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	1	0	5	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	20	0	1	0	0	0
Peridinium,	3	pr.	2	2	5	4	28	6	2	3	2	5
Trachelomonas,	0	1	1	pr.	pr.	1	1	2	3	0	0	0
Vermes,	3	4	pr.	pr.	pr.	1	1	1	0	1	1	0
Anuræa,	2	1	0	pr.	pr.	1	1	1	0	1	1	0
Polyarthra,	1	3	0	0	0	0	0	0	0	0	0	0
Rotatorian ova,	0	pr.	pr.	0	pr.	0	0	0	0	0	0	0
Miscellaneous,	10	0	0	932	42	22	36	340	36	172	70	8
Acarina,	0	0	0	0	0	0	0	.10	.04	.02	0	0
Zoöglœa,	10	0	0	982	42	22	36	340	36	172	70	8
TOTAL,	1199	2602	150	1242	509	176	207	974	2730	3492	419	118

Aeration.

Provision was made in the year 1891 for aerating the water supplied to the city of Brockton by forcing air into it through a system of perforated pipes laid near the bottom of the iron tank, as described in the Annual Report of this Board for 1892, page 110. The tank is 62 feet in diameter and 59 feet 4 inches in height, and is open at the top. In the following table is given a comparison of analyses of samples of water collected as it comes from the reservoir and after aeration in the tank.

BROCKTON.

Comparison of Examinations of Water from the Brockton Water Works before and after Aeration in the Open Tank.

NOTE. — Figures in bold-face type show results of examinations before aeration. Figures in Roman type show results of examinations after aeration.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
	1893.					
10087	**Mar. 7**	**Sli't.**	**V. sl't.**	**0.90**	**Distinctly vegetable and unpleasant.**	**Distinctly vegetable, sweetish, unpleasant.**
10088	Mar. 7	Slight.	V. slight.	0.90	Distinctly* vegetable and unpleasant.	Distinctly* vegetable, sweetish, unpleasant.
10966	**Sept. 5**	**Dist't.**	**Slight.**	**0.60**	**Distinctly vegetable.**	**Distinctly vegetable.**
10967	Sept. 5	Dist't.	Cons., brown.	0.68	Distinctly vegetable.	Distinctly vegetable.
11138	**Oct. 4**	**Sli't.**	**Cons., green.**	**0.60**	**Faintly vegetable.**	**Distinctly vegetable and mouldy.**
11139	Oct. 4	Slight.	Cons., green.	0.55	Distinctly vegetable.	Dist'ly vegetable and mouldy.
11449	**Dec. 5**	**Sli't.**	**Cons.**	**0.65**	**V. faintly vegetable.**	**Very faintly vegetable.**
11450	Dec. 5	Dist't.	Heavy, rusty.	0.70	Distinctly vegetable and unpleasant.	Very faintly vegetable.
Av.	....	....	....	**0.69**	....	....
Av.	....	....	....	0.71	....	....

* Somewhat less strong than in 10087.

Comparison of Examinations of Water from the Brockton Water Works before and after Aeration in the Open Tank — Concluded.

Number.	Date of Collection.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.	Organisms per cubic centimeter.
	1893.													
10087	**Mar. 7**	**4.00**	**2.00**	**.0006**	**.0184**	**.0152**	**.0032**	**.38**	**.0000**	**.0000**	**.8064**	**1.4**	**.0150**	**150**
10088	Mar. 7	4.65	1.95	.0020	.0196	.0148	.0048	.47	.0030	.0000	.7884	1.	.0350	463
10966	**Sept. 5**	**3.40**	**1.70**	**.0016**	**.0260**	**.0222**	**.0038**	**.36**	**.0030**	**.0001**	**.6480**	**0.6**	**.0200**	**2,730**
10967	Sept. 5	3.20	1.55	.0024	.0262	.0236	.0026	.38	.0050	.0000	.6360	0.6	.0165	878
11138	**Oct. 4**	**3.00**	**1.75**	**.0000**	**.0312**	**.0268**	**.0044**	**.40**	**.0000**	**.0000**	**.5775**	**0.5**	**.0100**	**3,492**
11139	Oct. 4	3.10	1.50	.0018	.0292	.0204	.0088	.39	.0000	.0000	.5159	0.5	.0140	3,125
11449	**Dec. 5**	**4.00**	**1.65**	**.0006**	**.0276**	**.0240**	**.0036**	**.47**	**.0000**	**.0002**	**.6201**	**0.5**	**.0290**	**118**
11450	Dec. 5	3.95	1.80	.0012	.0320	.0228	.0092	.42	.0000	.0001	.5945	0.5	.0315	537
Av.	....	**3.60**	**1.78**	**.0007**	**.0258**	**.0221**	**.0038**	**.40**	**.0008**	**.0001**	**.6630**	**0.8**	**.0185**	**1,623**
Av.	....	3.73	1.70	.0019	.0268	.0204	.0064	.42	.0020	.0000	.6337	0.9	.0243	1,251

BROCKTON.

Table showing Height of Water in Salisbury Brook Storage Reservoir, Brockton, on Dates when Samples of Water were collected for Analysis.

NOTE. — High-water mark is 14.25 feet.

Date. — 1893.	Height of Water.	Date. — 1893.	Height of Water.
	Feet.		Feet.
Jan. 9,	14.17	July 11,	13.64
Feb. 7,	14.27	Aug. 8,	12.67
Mar. 7,	14.42	Sept. 5,	12.28
April 5,	14.50	Oct. 4,	11.85
May 8,	14.46	Nov. 7,	11.75
June 6,	14.26	Dec. 5,	11.75

Chemical Examination of Water from an Underdrain beneath the Main Sewer at Brockton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
11560	1893. Dec. 28	Decided, floc.	Cons., yellow.	0.02	13.80	-	.0160	.0080	-	-	1.78	.5500	.0020	.0885	4.2

Iron, .0420. Odor, faintly vegetable.—— The sample was collected from the underdrain at a man-hole near the Salisbury Plain River south of Perkins Avenue.

The sewerage system of the City of Brockton had not been completed at the time this sample was collected and no sewage had been admitted to the sewers. The sample therefore indicates the average character of the ground water of the region through which the sewer passes.

Microscopical Examination.

Fungi, *Crenothrix*, 1920. Miscellaneous, *Zoöglœa*, 320. Total, 2240.

BROOKFIELD.

WATER SUPPLY OF BROOKFIELD.

Chemical Examination of Water from the Brookfield Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
10640	1893. July 11	Decided, milky.	Cons., rusty.	0.5	6.60	.0006	.0230	.14	.0070	.0000	.2555	1.5	.1700

Odor, none; becoming faintly vegetable on heating. The sample was collected from a hydrant. The source of supply is a storage reservoir located upon a small brook. This is not a representative sample of the water as it enters the pipes from the reservoir.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 2. Cyanophyceæ, *Merismopedia*, 3. Algæ, *Closterium*, 1; *Protococcus*, 4; *Staurastrum*, 1. Fungi, *Crenothrix*, 84. Vermes, *Rotifer*, 1. Miscellaneous, *Zoöglœa*, 412. Total, 508.

WATER SUPPLY OF BROOKLINE.

An important addition was made to the Brookline Water Works in 1893 by the completion of a covered distributing reservoir, which resembles in its general design the covered reservoir constructed by the city of Newton in 1890 and described in the twenty-third annual report of this Board for 1891, page 185. The new reservoir is a rectangular chamber ninety-three feet four inches long, ninety-one feet four inches wide and nineteen and one-half feet deep. The walls are of rubble masonry, coated on the inside with a layer of Portland cement mortar, one-half an inch in thickness. The covering consists of four-inch brick arches, supported on lines of brick piers connected by brick lintel arches, the outer edges bearing on the surrounding walls. The piers are twenty-four inches square and twelve and one-half feet apart on centers. The bottom of the reservoir is formed of a layer of clay puddle two inches in thickness, over which is a layer of cement concrete four inches in thickness. The arches are covered with Portland cement concrete to a level four inches above their crown, and over all is a layer of loam eighteen inches in thickness. Tile drains four inches in diameter are laid beneath the loam in grooves in the concrete to carry off the

surplus rain-water. At the top of each line of arches is located a ventilator to allow a free circulation of air.

Water enters the reservoir near the bottom through a cast-iron main twenty inches in diameter, and is drawn out through the same pipe. Provision was made for drawing all the water out of the reservoir if necessary by giving the bottom a slight slope toward a gutter, the bottom of which also has a slight slope and conveys the water to a ten-inch pipe passing through the wall. The reservoir is provided with an overflow 16.2 feet above its bottom, and surplus water flows off in this way into the open distributing reservoir near by. The open reservoir is still retained for use in cases of emergency.

Water is now delivered to consumers without exposure to light at any point, and it is said that since the new reservoir was put in operation the consumers have been very well satisfied with the character of the water, and all complaints of bad tastes and odors have ceased.

Chemical Examination of Water from a Faucet at the Low Service Pumping Station and from the Covered Reservoir of the Brookline Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1898.												
11545	Dec. 26	None.	None.	0.0	9.15	.0026	.0026	.54	.0420	.0000	.1344	4.2	.0000
11546	Dec. 26	None.	None.	0.0	10.10	.0000	.0026	.56	.0800	.0004	.1176	4.2	.0375

Odor, none.——The first sample was collected from a faucet at the low service pumping station and represents the water as drawn from the filter-gallery or tubular wells. The last sample was collected directly from the new covered reservoir.

Microscopical Examination.

No. 11545. No organisms.
No. 11546. Fungi, *Crenothrix*, 18.

CAMBRIDGE.

WATER SUPPLY OF CAMBRIDGE.

Chemical Examination of Water from Fresh Pond, Cambridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9846	Jan. 4	Slight.	Cons.	0.30	7.60	1.55	.0248	.0216	.0194	.0022	.66	.0100	.0004	.3942	4.6
9967	Feb. 6	V. slight.	V. slight.	0.35	7.35	2.00	.0206	.0214	.0176	.0038	.65	.0400	.0005	.4197	3.5
10079	Mar. 6	V. slight.	Slight.	0.40	7.10	1.70	.0150	.0186	.0154	.0032	.68	.0350	.0001	.4248	3.5
10208	Apr. 4	Slight, clayey.	Slight.	0.30	6.45	1.40	.0128	.0182	.0156	.0026	.53	.0400	.0003	.4453	2.7
10349	May 3	Slight.	Cons., green.	0.30	6.85	2.25	.0062	.0340	.0262	.0078	.61	.0350	.0009	.4453	2.8
10480	June 5	Distinct, milky.	Slight.	0.35	6.40	1.45	.0058	.0206	.0182	.0024	.57	.0400	.0003	.4599	2.6
10585	July 5	Distinct.	Cons., green.	0.30	6.25	2.00	.0014	.0190	.0164	.0026	.51	.0300	.0003	.4582	3.1
10739	Aug. 7	Slight, green.	Slight, green.	0.25	5.90	2.00	.0000	.0156	.0100	.0056	.50	.0150	.0005	.2738	3.0
10963	Sept. 5	Distinct.	Slight, white.	0.20	6.05	2.00	.0010	.0208	.0174	.0034	.52	.0400	.0005	.4120	2.6
11132	Oct. 3	V. slight.	Cons., green.	0.10	6.15	2.15	.0014	.0176	.0188	.0088	.47	.0150	.0006	.3465	3.0
11294	Nov. 6	V. slight.	Slight.	0.20	6.75	1.45	.0206	.0158	.0186	.0022	.65	.0220	.0013	.4482	3.2
11456	Dec. 5	Slight.	Cons., green.	0.20	7.05	1.85	.0174	.0188	.0142	.0046	.63	.0200	.0012	.3237	3.2
Av.	....	....	....	0.27	6.66	1.82	.0106	.0202	.0165	.0037	.58	.0285	.0006	.4043	3.2

Averages of Analyses of Previous Years.

-	1887*	-	-	0.04	17.32	1.94	.0105	.0180	-	-	2.11	.0266	-	-	-
-	1888	-	-	0.17	11.11	1.79	.0132	.0206	-	-	1.10	.0261	.0007	-	-
-	1889	-	-	0.11	9.86	1.83	.0145	.0220	.0170	.0050	0.90	.0334	.0008	-	-
-	1890	-	-	0.11	8.87	1.41	.0098	.0221	.0168	.0053	0.83	.0303	.0004	-	4.1
-	1891	-	-	0.15	7.94	1.80	.0095	.0235	.0162	.0073	0.75	.0333	.0004	-	3.8
-	1892	-	-	0.16	7.23	1.57	.0086	.0210	.0161	.0049	0.67	.0249	.0003	-	3.4
-	1893	-	-	0.27	6.66	1.82	.0106	.0202	.0165	.0037	0.58	.0285	.0006	.4043	3.2

* June to December.

NOTE to analyses of 1893; Iron, .0110. Odor, generally vegetable, often none. On heating, the odor was generally somewhat stronger, and none of the samples were odorless.——The samples were collected from the pump well at the pumping station. For a record of heights of water in this pond at times when samples of water were collected for analysis see page 136.

It will be noticed from an examination of the averages of analyses of previous years, that there has been a decrease from year to year in the amounts of solids and chlorine in the water of this pond since the examinations were begun, accompanied by a general though not regular increase in color. These changes are due to the introduction of water from Stony Brook into Fresh Pond, which began early in November, 1887, at a time when the water in Fresh Pond was very low. The quantity of water turned into the pond from the brook increases from year to year with the rapidly increasing consumption of water in Cambridge, and the character of the water in the pond is consequently approaching that of the water in the brook.

CAMBRIDGE.

Microscopical Examination of Water from Fresh Pond, Cambridge.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, .	5	7	7	5	3	7	5	8	6	3	9	7
Number of sample, .	9846	9967	10079	10208	10349	10480	10585	10739	10968	11132	11294	11456
PLANTS.												
Diatomaceæ, . .	2,116	363	411	794	1,338	664	612	931	126	1,070	693	3,084
Asteriolampra, . .	0	0	322	686	0	0	0	0	0	0	0	0
Asterionella, . .	396	44	12	18	108	19	56	22	12	1012	5	152
Cyclotella, . . .	296	264	62	62	0	44	88	104	110	3	44	104
Diatoma, . . .	3	9	pr.	0	0	0	0	2	0	0	0	0
Fragilaria, . . .	106	0	1	0	61	7	8	10	0	0	4	40
Melosira, . . .	536	10	0	16	640	12	0	31	0	0	370	2160
Stephanodiscus, .	432	1	2	5	390	pr.	0	1	0	0	pr.	88
Synedra, . . .	3	0	1	3	26	2	0	45	1	0	0	0
Tabellaria, . .	344	35	11	4	118	580	460	716	3	55	270	520
Cyanophyceæ, .	1	0	0	0	0	pr.	20	172	10	0	0	0
Anabæna, . . .	0	0	0	0	0	0	15	12	10	0	0	0
Clathrocystis, . .	1	0	0	0	0	pr.	5	8	pr.	0	0	0
Microcystis, . .	0	0	0	0	0	0	0	152	0	0	0	0
Algæ, ...	69	6	1	31	2	10	170	204	1	1	25	7
Chlorococcus, . .	1	0	0	1	0	0	0	0	0	0	0	4
Closterium, . .	64	3	1	2	0	0	0	3	0	0	1	1
Eudorina, . . .	0	0	0	0	0	0	0	0	0	0	16	0
Protococcus, . .	0	0	0	0	0	6	168	184	0	0	5	0
Scenedesmus, . .	4	3	pr.	0	2	1	1	4	0	0	pr.	0
Staurastrum, . .	0	0	0	0	0	1	1	4	1	1	3	2
Tetraspora, . .	0	0	0	0	0	0	0	8	0	0	0	0
Zoöspores, . .	0	0	0	28	0	2	0	1	0	0	0	0
Fungi, Crenothrix, .	1	4	pr.	1	0	0	0	0	0	30	80	0
ANIMALS.												
Rhizopoda, . .	3	0	0	0	0	0	1	0	1	2	0	28
Actinophrys, . .	3	0	0	0	0	0	1	0	pr.	2	pr.	28
Difflugia, . . .	0	0	0	0	pr.	0	0	0	1	0	0	0
Infusoria, . . .	39	1	0	2	pr.	3	5	2	pr.	4	42	4
Ciliated infusorian, .	0	0	0	0	0	1	0	0	0	0	0	0
Dinobryon cases, .	0	0	0	0	0	0	0	0	0	0	20	0
Monas, . . .	0	0	0	0	pr.	1	1	0	0	0	0	0
Peridinium, . .	0	0	0	pr.	0	0	0	2	pr.	3	pr.	0
Suctoria, . . .	38	0	0	0	0	0	0	0	0	0	0	0
Trachelomonas, .	1	1	0	2	0	1	4	0	0	1	22	4
Vermes, . . .	0	0	0	1	0	0	0	1	0	0	pr.	0
Anurea, . . .	0	0	0	1	0	0	0	0	0	0	pr.	0
Polyarthra, . .	0	0	0	0	0	0	0	1	0	0	pr.	0
Miscellaneous,	44	13	80	30	0	2	92	52	10	64	24	2
Acarina, . . .	0	0	0	0	.05	.04	.02	0	0	0	0	0
Zoöglœa, . . .	44	13	80	30	0	2	92	52	10	64	24	2
TOTAL, . . .	2,273	387	492	859	1,340	679	900	1,362	148	1,191	864	3,105

CAMBRIDGE.

Chemical Examination of Water from Stony Brook Storage Reservoir, Waltham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.*	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9855	Jan. 9	V.slight.	Slight.	0.55	6.50	2.50	.0040	.0228	.0196	.0032	.49	.0350	.0001	.5680	2.5
9978	Feb. 7	V.slight.	Slight.	0.55	6.10	1.95	.0080	.0186	.0160	.0026	.48	.0600	.0002	.5037	2.6
10077	Mar. 6	V.slight.	V.slight.	0.80	6.00	2.25	.0036	.0284	.0258	.0026	.39	.0500	.0000	.7056	2.2
10209	Apr. 4	Slight.	Slight.	0.65	4.40	1.70	.0008	.0214	.0186	.0028	.32	.0350	.0000	.5949	1.1
10356	May 4	V.slight.	Slight.	1.00	4.70	1.90	.0012	.0240	.0216	.0024	.35	.0100	.0003	.7592	1.5
10472	June 5	Slight.	Slight.	1.20	4.90	1.95	.0014	.0236	.0204	.0032	.37	.0070	.0001	.8250	1.7
10599	July 5	Distinct.	Slight.	0.75	5.50	2.45	.0002	.0244	.0224	.0020	.41	.0250	.0002	.6424	1.9
10740	Aug. 7	Distinct, green.	Slight, green.	0.45	4.30	1.60	.0016	.0186	.0152	.0034	.40	.0000	.0000	.3589	2.3
10965	Sept. 5	Decided.	Slight, brown.	0.65	4.90	1.80	.0004	.0280	.0204	.0076	.42	.0060	.0000	.5360	2.1
11133	Oct. 3	Distinct.	Cons.	0.12	4.80	1.95	.0002	.0184	.0140	.0044	.57	.0000	.0000	.4196	2.3
11290	Nov. 6	Distinct.	Cons., green.	0.65	5.65	1.55	.0016	.0264	.0202	.0062	.55	.0090	.0003	.6640	2.2
11448	Dec. 5	Distinct.	Slight.	0.55	6.10	2.00	.0004	.0270	.0206	.0064	.54	.0130	.0003	.5694	2.2
Av.	....	....	....	0.66	5.32	1.97	.0020	.0235	.0196	.0039	.44	.0208	.0001	.5956	2.1

Averages of Analyses of Previous Years.

-	1887*	-	-	0.81	6.21	1.82	.0049	.0347	-	-	.43	.0035	-	-	-
-	1888	-	-	0.78	5.15	1.93	.0031	.0285	-	-	.34	.0169	.0002	-	-
-	1889	-	-	0.87	4.59	1.47	.0032	.0280	.0249	.0031	.38	.0162	.0003	-	-
-	1890	-	-	0.61	5.86	2.02	.0016	.0222	.0182	.0040	.37	.0208	.0002	-	2.3
-	1891	-	-	0.56	4.99	1.86	.0016	.0213	.0183	.0030	.34	.0163	.0001	-	1.9
-	1892	-	-	0.72	5.43	1.79	.0015	.0241	.0202	.0039	.37	.0208	.0001	-	2.2

* June to November.

Note to analyses of 1893; Iron, .0149. Odor, generally distinctly vegetable, rarely unpleasant. On heating the odor often becomes stronger, and sometimes disagreeable.——The samples were collected from the reservoir near the surface at the dam. For heights of water in this reservoir at times when samples of water were collected for analysis see page 136.

CAMBRIDGE.

Microscopical Examination of Water from Stony Brook Storage Reservoir, Waltham.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	9	7	5	5	6	7	8	6	4	8	7
Number of sample,	9855	9978	10077	10209	10356	10472	10599	10740	10965	11133	11290	11443
PLANTS.												
Diatomaceæ,	**98**	**14**	**0**	**27**	**102**	**99**	**2,347**	**501**	**2,008**	**268**	**1,352**	**1,171**
Asterionella,	11	0	0	0	0	4	700	13	0	33	520	360
Cyclotella,	17	0	0	pr.	pr.	6	7	420	1,400	52	68	88
Diatoma,	1	0	0	0	2	0	0	0	420	0	0	1
Fragilaria,	8	0	0	0	5	0	0	0	14	25	4	0
Melosira,	12	0	0	0	0	0	0	0	0	0	0	0
Meridion,	0	0	0	20	1	0	0	0	0	0	0	0
Navicula,	1	0	0	pr.	1	1	0	1	2	2	0	1
Synedra,	6	14	0	3	82	4	740	15	76	28	0	1
Tabellaria,	42	pr.	0	4	11	84	900	52	96	128	760	720
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**9**	**25**	**61**	**0**	**0**
Anabæna,	0	0	0	0	0	0	0	8	19	1	0	0
Clathrocystis,	0	0	0	0	0	0	0	1	6	0	0	0
Cœlosphærium,	0	0	0	0	0	0	0	0	0	60	0	0
Algæ,	**0**	**0**	**0**	**0**	pr.	**0**	**101**	**8**	**48**	**0**	**0**	**4**
Closterium,	0	0	0	0	pr.	0	1	3	40	0	0	0
Protococcus,	0	0	0	0	0	0	100	0	5	0	0	4
Staurastrum,	0	0	0	0	0	0	0	5	3	0	0	0
ANIMALS.												
Rhizopoda,	**3**	**0**	**0**	**0**	pr.	**0**	**0**	**0**	**1**	**0**	**4**	**0**
Actinophrys,	3	0	0	0	0	0	0	0	0	0	4	0
Difflugia,	0	0	0	0	pr.	0	0	0	1	0	0	0
Infusoria,	**0**	pr.	**0**	**0**	**2**	**1,607**	**196**	**40**	**15**	**3**	**0**	**0**
Dinobryon,	0	0	0	0	0	0	4	0	10	0	0	0
Dinobryon cases,	0	0	0	0	1	1,600	192	0	0	0	0	0
Euglena,	0	0	0	0	0	0	0	0	2	0	0	0
Peridinium,	0	0	0	0	1	0	0	40	2	1	0	0
Trachelomonas,	0	pr.	0	0	0	7	0	0	1	2	0	0
Miscellaneous,	**100**	**3**	**13**	**0**	**7**	**52**	**2**	**48**	**2**	**100**	**28**	**36**
Acarina,	0	0	0	0	0	0	.02	.01	.04	0	0	0
Zoöglœa,	100	3	13	0	7	52	2	48	2	100	28	36
TOTAL,	196	17	13	27	111	1,758	2,646	606	2,099	432	1,384	1,211

CAMBRIDGE.

Table showing Heights of Water in Fresh Pond and in Stony Brook Storage Reservoir on the Dates when Samples of Water were collected for Analysis.

[Heights are in feet above Cambridge city base.]

FRESH POND. HIGH WATER, 16.85.		STONY BROOK RESERVOIR. ROLLWAY, 81.00.	
DATE.	Height of Water.	DATE.	Height of Water.
1893.		1893.	
Jan. 4,	14.95	Jan. 9,	79.20
Feb. 6,	15.05	Feb. 7,	75.92
Mar. 6,	16.31	Mar. 6,	81.14
April 4,	16.85	April 4,	81.59
May 3,	16.89	May 4,	81.75
June 5,	16.68	June 5,	81.14
July 5,	16.90	July 5,	79.75
Aug. 7,	16.72	Aug. 7,	72.00
Sept. 5,	16.54	Sept. 5,	65.10
Oct. 3,	13.90	Oct. 3,	66.32
Nov. 6,	11.84	Nov. 6,	71.84
Dec. 5,	12.65	Dec. 5,	71.75

WATER SUPPLY OF CANTON.

The advice of the State Board of Health to the town of Canton relative to a proposed additional water supply from the valley of Beaver Brook above the present pumping station of the Canton Water Works, may be found on pages 14 and 15 of this volume. In the following table is given the analyses of samples of water collected in connection with the investigation for this additional water supply.

Chemical Examination of Water from Tubular Test Wells, in the Valley of Beaver Brook, Canton.

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9922	Jan. 24	V. slight, clayey.	V. slight, earthy.	0.00	3.75	.0000	.0006	.42	.0150	.0001	.0000	1.3	.0110
9923	Jan. 24	Decided, milky.	Cons., rusty.	0.03*	6.60	.0234	.0012	.21	.0120	.0000	.0109	2.3	.4100
9957	Feb. 1	None.	V. slight.	0.02	5.65	.0000	.0006	.32	.0000	.0000	.0197	2.7	.0060

* This sample when received at the laboratory had a color of 0.70 caused by minute particles of iron rust in suspension, but subsequently, after the iron rust had precipitated, became nearly colorless.

Odor, of No. 9923, faint; of the others, none.——Sample No. 9922 was collected from tubular test well No. 2, 20 feet deep, driven through 11 feet of muck and five feet of sand into gravel. No. 9923, from test well No. 3, 20.5 feet deep, driven through 1.45 feet of muck and 2 feet of fine sand into gravel. No. 9957, from test well No. 5, 20 feet deep, driven through 5 feet of muck and 5 feet of fine sand into gravel. Water was pumped from the wells with a hand pump before collecting the samples, for periods varying from 2 to 4½ hours. The wells were located in the vicinity of Beaver Brook, at a point where it is joined by a small branch from the south, about half a mile above the pumping station of the Canton Water Works.

Microscopical Examination.

No organisms.

Water Supply of Chelsea.

(See *Boston, Mystic Works.*)

Water Supply of Chester.

Description of Works. — The population of the town in 1890 was 1,295. The population of the main village, which is the only portion of the town supplied with water, is said to be about 800. The works are owned by C. L. Goodhue. Water was introduced in November, 1893, and was supplied to about 60 families at the end of the year.

The source of supply is Austin Brook, a tributary of Walker Brook. Water is drawn from Austin Brook at a point about 1,200 feet from its mouth, and less than a mile west of the village of Chester, where a small reservoir has been constructed at a sufficient elevation to supply the town by gravity. It is said that the reservoir is formed by a dam about 8 feet in height, and covers an area 60x80 feet to an average depth of about 6 feet.

The brook, above the point where the dam is located, drains an area about 1¼ square miles, which is mainly pasture and woodland; it is said that there is but one dwelling house on this area.

The distributing mains are of cast-iron, and the service pipes are of galvanized iron.

The advice of the State Board of Health to the town of Chester, with reference to taking a supply of water from Austin and other brooks, may be found on pages 15 to 17 of this volume.

Chemical Examination of Water from Austin, Blandford and Walker Brooks, and Horn Pond in Chester and Becket.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10430	May 22	None.	V. slight.	0.08	2.40	0.65	.0008	.0046	.0038	.0008	.05	.0000	.0000	.2062	0.8
10431	May 22	None.	V. slight.	0.08	2.75	0.75	.0010	.0052	.0044	.0008	.06	.0030	.0000	.2062	0.8
10432	May 22	V. slight.	Slight.	0.30	2.60	1.05	.0006	.0158	.0130	.0028	.05	.0050	.0001	.4162	0.8
10433	May 22	V. slight.	V. slight.	0.48	3.05	1.05	.0006	.0104	–	–	.04	.0000	.0000	.4987	0.8

Iron, in No. 10430, .0050; in No. 10431, .0025; in the remaining samples, none. Odor of the first two samples, none; of the third, distinctly vegetable, disappearing on heating; of the last, very faintly vegetable. —— The first sample was collected from Austin Brook; the second, from Blandford Brook, about a third of a mile from its mouth; the third, from Walker Brook, about a mile from the Chester railroad station, and the last from Horn Pond.

Microscopical Examination.

The number of organisms per cubic centimeter in these samples was as follows: No. 10430, 1; No. 10431, 9; No. 10433, not examined; No. 10432, 45.

CHICOPEE.

Water Supply of Chicopee.

Until 1893 the city of Chicopee had been supplied with water from various sources as follows: —

Chicopee Centre, having a population in 1890 of about 7,500, was supplied with water by the Chicopee Water Company from Dingle Brook, and from wells, partly by gravity and partly by pumping.

Chicopee Falls (population in 1890, 5,553) was supplied chiefly from works owned by the district, with water pumped by the Chicopee Manufacturing Company from the Chicopee River within the village.

Willimansett Village (population in 1890, about 300) was supplied by the Willimansett Aqueduct Company with water by gravity from a small brook.

In 1892 the city of Chicopee acquired possession of the works of the Chicopee Water Company and of the Willimansett Aqueduct Company.

In the winter and early spring of 1892 there was a mild epidemic of typhoid fever in Chicopee Falls, and the State Board of Health, after investigation,* found reason to believe that the epidemic was due to the use of water from the Chicopee River, a stream which receives the sewage of several thousand people, and taking these results in connection with investigations in other places showing that a polluted running stream is a very dangerous source of water supply, advised the city to secure a pure water supply for Chicopee Falls and to discontinue the use of river water. The new supply was completed at the end of 1893, and the use of water from the Chicopee River was discontinued.

Description of Works. — The new sources of supply are Morton and Cooley Brooks, the waters of which are taken near their confluence, about 1½ miles northeast of Chicopee Falls. Cooley Brook is a tributary of the Chicopee River from the north, and a large part of its course is through a ravine in the great sandy plain between Chicopee and Granby. Owing to the character of its watershed, which allows much of the water falling upon it to pass into the ground and move gradually toward the brook, which it finally reaches in the form of springs, its flow is well maintained in a dry

* See "An Investigation of an Outbreak of Typhoid Fever in Chicopee Falls apparently due to infected Water Supply," made under the direction of Prof. W. T. Sedgwick in the twenty-fourth annual report of the State Board of Health for 1892, pages 705-714.

season. A dam about 170 feet long and 10 feet in height has been constructed across the brook at a point about three-fourths of a mile from its mouth, forming a small reservoir said to have a capacity when full of 5,500,000 gallons. All the loam and vegetable matter was removed from the area to be flowed up to the level at which it is proposed to hold the water, which for the present will be only high enough to divert the water into a conduit leading to the pumping station.

Morton Brook is a small branch of Cooley Brook, fed almost wholly by springs, which enters the latter a short distance below the dam just described. A low dam has been constructed across this brook a short distance above its mouth, forming a small reservoir about 80 feet long, 40 feet wide, and averaging three feet in depth, which was thoroughly cleaned.

A cast-iron conduit pipe 16 inches in diameter conveys water by gravity from Cooley Brook to a receiving basin at the pumping station, a distance of 2,434 feet. A branch conduit 8 inches in diameter, also of cast-iron, conveys the water from Morton Brook to the main conduit, a distance of 750 feet. It is proposed to take the supply as far as possible from Morton Brook, because of the better quality of its water.

The receiving basin is 107 feet long, 77 feet wide and 8 feet deep at high water. It is oval in shape, with sloping sides, and has a capacity of 350,000 gallons. The slopes are paved with bricks laid in cement, and the bottom is covered with a layer of Portland cement concrete, 6 inches in thickness, over which is a layer of gravel 4 inches in thickness. At the end of the basin where the conduit enters, there is a sand chamber 9 feet long, 6 feet wide and 8 feet deep, designed to catch heavy suspended matter, and from this chamber the water overflows into the main portion of the basin. The surplus water brought to the basin passes off through an overflow formed by a 20-inch pipe set perpendicularly in the centre of the basin, and discharging into a pipe leading to Cooley Brook.

Water is pumped from the basin to the city and to an open iron tank 55 feet in diameter and 60 feet in height, situated a short distance from the main pipe between the pumping station and the city. All new distributing mains are of cast-iron; new service pipes are of galvanized iron and lead.

CHICOPEE.

The old works of the Chicopee Water Company will still be used as a low-service supply for the lower portion of the city.

The water supply of the village of Willimansett was introduced in the summer of 1892. The source of supply is a small brook, a tributary of the Connecticut River from the east, which flows from the westerly side of the great sandy plain already mentioned. A dam about 10 feet in height has been constructed across the brook, forming a small reservoir at a point where the elevation is sufficient to supply the village by gravity. Distributing mains are of cast-iron. Service pipes are of galvanized iron and lead.

Chemical Examination of Water from Morton and Cooley Brooks in Chicopee.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
11399	Nov. 27	V. slight.	Cons. sandy.	0.02	3.50	0.40	.0000	.0104	.0094	.0010	.13	.0180	.0000	.1505	1.6
11400	Nov. 27	V. slight.	Cons. earthy & sandy.	0.02	3.45	0.65	.0000	.0044	.0016	.0028	.09	.0080	.0000	.1462	1.4

Iron, in No. 11399, .0050; in No. 11400, .0050. Odor, very faintly vegetable, disappearing on heating.——The first sample was collected from the receiving basin at the pumping station and represents water from Morton Brook. The second sample was collected from Cooley Brook at the new dam.

Microscopical Examination.

No. 11399. Diatomaceæ, *Meridion*, 1; *Synedra*, 1. Fungi, *Cladothrix*, 2. Miscellaneous, *Zoöglœa*, 5. Total, 9.

No. 11400. Diatomaceæ, *Gomphonema*, 1; *Navicula*, 2; *Synedra*, 1; *Tabellaria*, 1. Algæ, *Closterium*, 1. Fungi, *Crenothrix*, 2. Miscellaneous, *Zoöglœa*, 6. Total, 14.

COHASSET.

WATER SUPPLY OF COHASSET. — COHASSET WATER COMPANY.

Chemical Examination of Water from the Tubular Wells of the Cohasset Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1893.												
10137	Mar. 17	Distinct, milky.	Slight, rusty.	0.12	21.15	.0008	.0002	1.93	.0180	.0000	.0079	11.6	.0650
10551	June 22	Slight, milky.	None.	*0.00	16.50	.0000	.0028	1.63	.0180	.0000	.0395	7.8	.0270
11069	Sept. 19	Distinct, milky.	Slight.	0.10	16.50	.0000	.0006	1.61	.0350	.0001	.0369	7.6	.0500
11096	Sept. 26	Distinct, milky.	None.	0.20	16.20	.0000	.0004	1.41	.0200	.0001	.0738	8.0	.0300
11215	Oct. 17	Distinct, milky.	None.	0.18	16.10	.0000	.0000	1.63	.0400	.0000	.0445	8.1	.0385
11349	Nov. 18	Distinct, milky.	None.	0.20	16.40	.0000	.0000	1.61	.0270	.0001	.0462	8.6	.0600
Av.	....	....	....	0.16	17.14	.0001	.0007	1.64	.0263	.0001	.0415	8.6	.0451

Averages of Analyses of Previous Years.

-	1887†	-	-	0.00	15.21	.0005	.0016	1.69	.0196	-	-	-	-
-	1888	-	-	0.01	15.20	.0001	.0021	1.50	.0311	.0003	-	-	-
-	1889‡	-	-	0.00	11.64	.0001	.0022	1.46	.0230	.0002	-	-	-
-	1890§	-	-	0.00	-	.0000	.0048	1.48	.0150	.0003	-	-	-
-	1893	-	-	0.16	17.14	.0001	.0007	1.64	.0263	.0001	.0415	8.6	.0451

* This sample was turbid when received and the color was determined after filtration.
† June to December. ‡ January to May. § February.

NOTE to analyses of 1893: Odor, none. —— The samples were collected from a faucet in the pumping station while pumping.

This water is beginning to show some of the characteristics of an "iron" water, namely, a noticeable turbidity, sediment and color, and the presence of iron and of certain microscopic organisms often found in such waters. The determinations of turbidity, sediment and color in a sample of water of this class vary with the length of time that the water has been exposed to the air after it has been drawn from the ground, since they are dependent upon the amount of iron which has been thereby oxidized and converted into an insoluble form. When the iron is all precipitated out, the water

COHASSET.

resumes its original appearance, free from color and turbidity. These results of turbidity, sediment and color are, therefore, only of value as showing a condition which the water may assume, and should not be used for making comparisons between the different samples.

Microscopical Examination of Water from the Tubular Wells of the Cohasset Water Company.

[Number of organisms per cubic centimeter.]

	1893.					
	March.	June.	Sept.	Sept.	Oct.	Nov.
Day of examination,	18	23	22	28	20	21
Number of sample,	10137	10551	11069	11096	11218	11349
PLANTS.						
Fungi, Crenothrix,	0	8	1,200	44	40	120
Miscellaneous, Zoöglœa,	0	3	24	24	7	42
TOTAL,	0	11	1,224	68	47	162

WATER SUPPLY OF CONCORD.

Chemical Examination of Water from Sandy Pond, Lincoln.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10141	Mar. 20	Slight.	Slight.	0.05	1.70	0.60	.0068	.0148	.0120	.0028	.21	.0000	.0000	.1620	0.6
10269	Apr. 19	V. slight.	V. slight.	0.08	2.20	0.60	.0002	.0086	.0060	.0020	.24	.0000	.0001	.1642	0.5

Iron, .0098. Odor, none; on standing two days, a faintly unpleasant odor developed in the first sample. On heating, a faint odor was developed in each sample.——The first sample was collected from the pond; the last, from a faucet in the town.

Microscopical Examination.

No. 10141. Diatomaceæ, *Asterionella*, 1; Vermes, *Anurea*, Pr.; Total, 1.

No. 10269. Diatomaceæ, *Asterionella*, Pr.; Infusoria, *Dinobryon*, 1; *Dinobryon cases*, 10. Total, 11.

WATER SUPPLY OF DANVERS.

In the act of the legislature giving the town of Danvers the right to supply itself with water, the town was granted permission to take its supply from Middleton Pond, in Middleton, and Swan's Pond, in North Reading. The latter is situated a little less than half a mile from Middleton Pond and its surface is about twenty-two feet higher. Water was introduced from Middleton Pond in 1876, but the works were not extended to Swan's Pond until 1893, when a connection between the two ponds was made by laying a six-inch cast-iron pipe. Swan's Pond is said to have an area of about forty-five acres.

WATER SUPPLY OF DEDHAM. — DEDHAM WATER COMPANY.

Chemical Examination of Water from the Well of the Dedham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9920	Jan. 24	None.	None.	0.0	10.15	.0000	.0016	.98	.2400	.0001	-	4.4	.0000
10461	May 31	None.	None.	0.0	10.80	.0000	.0012	.92	.2500	.0000	.0637	4.0	.0000
10674	July 18	None.	None.	0.0	10.10	.0000	.0018	.88	.2500	.0000	.0780	3.9	.0000
11356	Nov. 21	None.	None.	0.0	9.50	.0000	.0050	.90	.1900	.0000	.0924	4.3	.0000
Av...	....	....	....	0.0	10.14	.0000	.0024	.92	.2325	.0000	.0780	4.2	.0000

Averages of Analyses of Previous Years.

-	1887*	-	-	0.0	10.97	.0002	.0012	.97	.2690	-	-	-	-
-	1888†	-	-	0.0	10.38	.0002	.0011	.93	.2310	.0000	-	-	-
-	1889‡	-	-	0.0	9.15	.0000	.0020	.93	.1700	.0000	-	-	-
-	1892	-	-	0.0	10.65	.0000	.0006	.95	.2982	.0000	-	4.4	.0007
-	1893	-	-	0.0	10.14	.0000	.0024	.92	.2325	.0000	.0780	4.2	.0000

* June to December. † January to May. ‡ April.

NOTE to analyses of 1893: Odor, none.——The samples were collected from a faucet at the pumping station.

Microscopical Examination, 1893.

A very few organisms, chiefly Diatomaceæ, were found in Nos. 10461 and 10674. No organisms were found in the remaining samples.

DEDHAM.

Chemical Examination of Water from the New Open Tank of the Dedham Water Company, on Federal Hill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9921	Jan. 24	None.	None.	0.00	10.35	.0000	.0020	.96	.2400	.0001	.0036	4.6	.0050
10460	May 31	Slight.	Cons., green.	0.02	11.00	.0000	.0110	.90	.2300	.0000	.1312	4.0	.0050
10673	July 18	Slight.	Slight.	0.00	11.00	.0046	.0048	.89	.2250	.0001	.1638	4.4	.0430
11357	Nov. 21	Slight.	V. slight.	0.00	9.60	.0010	.0114	.89	.2550	.0001	.1848	4.3	.0025
Av.	1893	....	....	0.01	10.49	.0014	.0073	.91	.2375	.0001	.1209	4.3	.0139
Av.	1892	....	....	0.01	10.80	.0002	.0054	.98	.2962	.0001	-	4.4	.0108

Odor, of No. 10673, unpleasant; of the others, none. On heating, a distinctly vegetable and unpleasant odor was developed in No. 10460.—The samples were collected from the tank.

The supply of the Dedham Water Company is drawn from a covered well near Charles River, and previous to 1890 a single open tank twenty feet in diameter and one hundred and three feet high was used in connection with the distributing system. In 1890 a new tank forty-two feet in diameter and fifty-one feet high was added to the works. This tank like the first was not covered, but owing to its great diameter in proportion to its height the water has been exposed much more freely to the light, and in consequence abundant growths of microscopic organisms have appeared in the water and given it at times an unpleasant odor. The conditions in this case are similar to those at Brookline in 1887, when water from a filter-gallery near Charles River was pumped into a similar iron tank in which the organisms grew abundantly until August of that year when it was covered to exclude the light. After covering, the organisms disappeared and there has been no further trouble.

Microscopical Examination of Water from the New Open Tank of the Dedham Water Company, on Federal Hill.

[Number of organisms per cubic centimeter.]

	1893.			
	January.	June.	July.	November.
Day of examination,	25	1	20	22
Number of sample,	9921	10460	10673	11357
PLANTS.				
Diatomaceæ,	52	5,720	340	1,053
Asterionella,	0	520	0	1,040
Fragilaria,	52	5,200	340	13
Miscellaneous, Zoöglœa,	0	0	30	0
TOTAL,	52	5,720	370	1,053

DEERFIELD.

Chemical Examination of Water from Mill River and Clapp's Trout Brool Deerfield and Roaring Brook in Whately.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.
								Albuminoid.						
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.	
	1892.													
11401	Nov.27	None.	V.slight.	0.00	7.35	0.50	.0000	.0026	.0020	.0006	.11	.0400	.0000	.1290
11402	Nov.27	None.	V.slight.	0.00	6.40	0.55	.0006	.0040	.0032	.0008	.10	.0120	.0000	.1204
11403	Nov.27	None.	V.slight.	0.04	6.00	0.55	.0002	.0052	.0042	.0010	.12	.0080	.0000	.1462

Iron, insignificant. Odor of all samples, very faintly vegetable. —— The first sample was collec from Mill River in Deerfield near the boundary line between Conway and Deerfield; the second, fr Clapp's Trout Brook, a tributary of Mill River in Deerfield, and the last from Roaring Brook in What Glen, in the northern part of Whately.

Microscopical Examination.

No. 11401. Diatomaceæ, *Navicula*, 1; *Pinnularia*, 1; *Synedra*, 10. Miscellaneous, *Zoöglœa*, Total, 15.

No. 11402. Diatomaceæ, *Synedra*, 5.

No. 11403. Diatomaceæ, *Synedra*, 3. Miscellaneous, *Zoöglœa*, 1. Total, 4.

WATER SUPPLY OF EAST BRIDGEWATER.

(See *Bridgewater*.)

WATER SUPPLY OF EASTHAMPTON.

Works for taking a water supply from a new source were built by the town in 1892, and the use of water from Williston Pond has been discontinued. The new source of supply is Bassett Brook, a stream which rises in Northampton and flows into the Manhan River, just opposite the village of Easthampton. Water is taken from the brook a little less than a mile from its mouth, at a point where a low dam has been constructed forming a small basin. From the basin water flows by gravity, through a cast-iron pipe twelve inches in diameter, to a pumping station located at a dam on the Manhan River, a short distance below the mouth of Bassett Brook. From this point the water is pumped by water

power, through a new cast-iron force main ten inches in diameter and one thousand two hundred and fifty feet in length, into the old system of distributing pipes in the village, the surplus water going to the distributing reservoir on Mt. Tom.

Bassett Brook, above the point of diversion, drains an area of about 6.9 square miles. In the upper portion of the watershed the slopes are steep, but in the middle and lower portions the surface is more nearly level, and there are considerable areas of flat land in the vicinity of the stream, some of which are swampy. There are no ponds or storage reservoirs on the watershed.

Water Supply of North Easton Village District, Easton.

Chemical Examination of Water from the Well of the North Easton Village District.

[Parts per 100,000.]

	...llection	Appearance.			...on ...uration	Ammonia.			Nitrogen as		...nsumed.	

FAIRHAVEN.

The results found by analysis are somewhat remarkable, as they show that water from flowing wells only a short distance apart differed very much in quality, some of the water having its origin in a polluted source, and some of it being the natural water of the region. This subject is referred to quite fully in the advice of the Board. It is also worthy of note that there was a difference in the temperature of the water from wells driven to the same depth, that from the southerly well having a temperature, April 12, 1893, of 46.5 degrees, from the northerly well, 43 degrees, and from the middle wells, 48 degrees. The temperature of the water in the river at the same time was 55 degrees.

The works for taking water from this source were nearly completed at the end of 1893.

Chemical Examination of Water from Tubular Test Wells in the Vicinity of the Nasketucket River, Fairhaven.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10190	Mar. 30	None.	V. slight.	0.02	10.15	.0002	.0026	1.48	.2200	.0000	.0146	3.1	.0000
10247	Apr. 12	None.	None.	0.00	3.90	.0000	.0004	0.81	.0480	.0000	.0182	1.3	.0015
10248	Apr. 12	None.	None.	0.00	12.60	.0000	.0022	1.93	.6000	.0000	.0146	3.9	.0050
Av.	....	....	....	0.01	8.88	.0001	.0017	1.41	.2893	.0000	.0158	2.8	.0022

Odor, none. On heating, the odor of the first sample became faintly vegetable.—— The wells are located in the vicinity of the river, about half a mile above the point where it is crossed by the Fairhaven branch of the N. Y., N. H. & H. R R. The first sample was collected from one of the middle wells in a line of six in the valley of the Nasketucket River; the second sample from the most northerly and the last from the most southerly well in this line.

Microscopical Examination.

No. 10190. Miscellaneous, *Zoöglœa*, 14.

Chemical Examination of Water from the Nasketucket River, Fairhaven.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Suspended.					
10249	1893. Apr 12	V. slight.	Slight.	1.90	5.55	2.60	.0006	.0228	.0202	.0026	.71	.0050	.0001	1.3468	0.8

Iron, .0030. Odor, faintly vegetable.——The sample was collected from the river at the dam of a small ice pond, located a short distance above the test wells.

Microscopical Examination.

Diatomaceæ, *Melosira*, 8; *Meridion*, 11; *Navicula*, 5; *Nitzschia*, 1; *Pinnularia*, 1; *Synedra*, 24; *Tabellaria*, 44. Miscellaneous, *Zoöglœa*, 6. Total, 106.

Water Supply of Falmouth Heights.—Falmouth Heights Water Company.

This village is a summer resort on Vineyard Sound in the southerly part of the town of Falmouth. The source of supply is a well about ten feet in diameter and twenty feet in depth, located a short distance north-west of the village. Water is pumped from the well to an elevated wooden tank upon Observatory Hill in the village, and is thence distributed to consumers through cast-iron mains. The reply of the State Board of Health to the Falmouth Heights Water Company, with reference to the use of this well as a source of water supply for the village of Falmouth Heights, may be found on page 18 of this volume.

Chemical Examination of Water from the Wells of the Falmouth Heights Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
10579	1893. June 20	Distinct, clayey.	Slight, white.	0.0	6.40	.0000	.0016	2.11	.0000	.0001	.0474	1.7	.0000

Odor, faintly earthy.——The sample was collected from the well.

Microscopical Examination.

No organisms.

FI

Water Supply of Fitchburg.

Chemical Examination of Water from Scott Reservoir, Fitchb

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitro… as	
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	
	1893.												
10685	July 19	Slight.	Slight.	0.10	2.60	1.55	.0000	.0332	.0246	.0086	.15	.0000	.0
11203	Oct. 16	Decided.	Cons., sandy.	0.15	2.20	1.15	.0000	.0292	.0180	.0112	.18	.0000	.0
11510	Dec. 18	None.	V. slight.	0.04	3.25	1.25	.0004	.0076	.0060	.0016	.19	.0100	.0
Av.	....	....	....	0.10	2.68	1.30	.0001	.0233	.0162	.0071	.17	.0038	.0

Averages of Analyses of Previous Years.

-	1887*	-	-	0.30	2.63	1.01	.0007	.0231	-	-	.15	.0021	-
-	1888	-	-	0.11	2.31	0.79	.0004	.0240	-	-	.13	.0040	.00
-	1889	-	-	0.09	2.12	0.62	.0008	.0213	.0162	.0051	.13	.0030	.00
-	1890	-	-	0.10	2.54	1.02	.0010	.0217	.0152	.0065	.13	.0059	.00
-	1891	-	-	0.13	2.55	1.05	.0007	.0146	.0110	.0036	.14	.0082	.00
-	1892	-	-	0.13	2.78	1.16	.0005	.0261	.0198	.0063	.18	.0089	.00
-	1893	-	-	0.10	2.68	1.30	.0001	.0233	.0162	.0071	.17	.0033	.00

* June to December.

Note to analyses of 1893: Iron, .0181. Odor of the first sample, distinctly unpleasan disagreeable on standing; of the other samples, faintly vegetable. — The samples were col the reservoir near the gate-house, one foot beneath the surface.

The heights of water in this reservoir on dates when samples of water were collected were as follows: July 19, thirty-seven feet; October 16, eighteen feet; December 18, feet. High-water mark is forty feet.

Microscopical Examination of Water from Scott Reservoir, Fitchbu

[Number of organisms per cubic centimeter.]

	1893.		
	July.	October.	De
Day of examination, ...	21	17	
Number of sample, ...	10685	11203	
PLANTS.			
Diatomaceæ, ...	142	2,500	
Asterionella, ...	15	36	
Diatoma, ...	2	0	
Melosira, ...	0	164	
Synedra, ...	116	0	
Tabellaria, ...	9	2,300	

FITCHBURG.

Microscopical Examination of Water from Meeting-house Pond, Westminster.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	25	28	23	26	24	21	21	25	20	17	24	20
Number of sample,	9918	10048	10152	10314	10437	10533	10684	10883	11051	11202	11377	11511
PLANTS.												
Diatomaceæ,	0	[illegible]	0	[illegible]	21	28	76	28	[illegible]	3	6	2
Cyclotella,	0	0	0	1	3	0	3	7	1	0	6	1
Melosira,	0	0	0	0	0	0	0	0	9	0	0	0
Synedra,	pr.	0	pr.	8	3	3	1	0	pr.	0	pr.	0
Tabellaria,	0	0	0	20	15	25	72	21	5	3	0	1
Cyanophyceæ,	0	0	[illegible]	0	0	1	68	1	13	[illegible]	0	[illegible]
Anabæna,	0	0	0	0	0	1	68	0	12	pr	0	0
Microcystis,	0	0	0	0	0	0	0	1	1	10	0	0
ANIMALS.												
Rhizopoda,												
Actinophrys,	1	[illegible]	0	0	0	0	0	0	0	0	0	0
Infusoria,	23	21	0	[illegible]	1	0	2	2	34	4	0	0
Cryptomonas,	18	0	0	0	0	0	0	0	0	0	0	0
Dinobryon,	0	6	0	67	0	0	0	0	0	0	0	0
Dinobryon cases,	5	16	0	35	1	0	0	0	0	0	0	0
Peridinium,	0	0	0	0	0	0	2	2	34	4	0	0
Miscellaneous, Zoöglœa,	0	1	0	0	2	[illegible]	44	3	0	8	[illegible]	0
TOTAL,	24	25	pr.	129	24	53	190	34	62	25	10	2

Chemical Examination of Water from Wyman's Reservoir, Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.				Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	[illegible]
	1893.														
10658	July 19	Distinct.	Cons.,red	1.30	4.20	2.40	.0040	.0476	.0318	.0158	.11	.0000	.0001	.8732	0.8
[illegible]	Aug. 22	Slight.	Slight.	1.40	4.00	2.45	.0168	.0342	.0314	.0028	.16	.0050	.0000	.9717	0.5

Iron, .0407. Odor of the first sample, musty and disagreeable, becoming offensive on heating; of the second sample, none, becoming faintly vegetable on heating. —— The samples were collected from the end of the pipe below the gate-house, and represent water drawn from the bottom of the reservoir. This reservoir is not used as a source of water supply, although it is owned by the city and is within the territory from which it is authorized to take water.

Microscopical Examination.

No. [illegible]. Diatomaceæ, *Synedra*, 80. Fungi, *Crenothrix*, 60. Infusoria, *Dinobryon cases*, 1. Vermes, *Anuræa*, 3. Miscellaneous, *Zoöglœa*, 380. Total, 524.

No. [illegible]. Diatomaceæ, *Cyclotella*, 1; *Synedra*, 6; *Tabellaria*, 3. Algæ, *Chlorococcus*, 4; *Closterium*, 1; *Raphidium*, 3. Fungi, *Crenothrix*, 5. Infusoria, *Dinobryon cases*, 3; *Peridinium*, 4; *Trachelomonas*, 1. Vermes, *Anuræa*, pr. Total, 30.

FRAMINGHAM.

Water Supply of Framingham.—Framingham Water Company.

Chemical Examination of Water from the Filter-gallery of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1893.												
10015	Feb. 14	None.	None.	0.02	5.60	.0036	.0032	.54	.0300	.0000	.1035	2.9	.0070
10243	April 11	None.	V. slight.	0.02	6.25	.0030	.0024	.51	.0550	.0001	.0730	2.5	.0055
10511	June 13	V. slight.	Slight.	0.05	6.20	.0028	.0036	.63	.0350	.0001	.0586	2.7	.0080
10800	Aug. 15	None.	Slight, rusty.	0.05	5.80	.0002	.0038	.60	.0020	.0001	.1422	2.3	.0050
11169	Oct. 11	V. slight.	Cons.	0.05	5.55	.0052	.0052	.73	.0180	.0000	.1498	2.3	.0250
11477	Dec. 12	Slight.	V. slight.	0.03	7.00	.0010	.0018	.70	.1360	.0001	.1400	3.1	.0090
Av.	....	....	....	0.04	6.07	.0026	.0033	.62	.0460	.0001	.1104	2.6	.0099

Averages of Analyses of Previous Years.

-	1887*	-	-	0.08	5.82	.0031	.0124	.43	.0123	-	-	-	-
-	1888	-	-	0.10	5.81	.0027	.0081	.44	.0308	.0004	-	-	-
-	1889	-	-	0.00	6.18	.0031	.0050	.56	.0366	.0002	-	-	-
-	1890	-	-	0.00	7.09	.0020	.0039	.65	.0631	.0001	-	3.0	-
-	1891	-	-	0.00	6.25	.0023	.0035	.63	.0707	.0001	-	2.8	-
-	1892†	-	-	0.13	5.43	.0051	.0081	.39	.0225	.0018	-	2.6	-
-	1893	-	-	0.04	6.07	.0026	.0033	.62	.0460	.0001	.1104	2.6	.0099

* June to November. † Two samples in October.

Note to analyses of 1893: Odor, none.——The first three samples were collected from a faucet at the pumping station while pumping; the last three were collected from the filter-gallery.

Microscopical Examination, 1893.

Nos. 10015 and 10511. No organisms.
Nos. 10243 and 11477. Fungi, *Crenothrix*, 2.
No. 10800. Fungi, *Crenothrix*, 68.
No. 11169. Fungi, *Crenothrix*, 55. Miscellaneous, *Zoöglœa*, 70. Total, 125.

FRAMINGHAM.

Chemical Examination of Water from a Faucet in South Framingham, supplied from the Works of the Framingham Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10016	Feb. 14	None.	None.	0.02	5.70	.0000	.0058	.56	.0250	.0002	.0922	3.3	.0100
10244	Apr. 11	None.	V. slight.	0.02	6.00	.0008	.0028	.49	.0500	.0005	.0547	2.5	.0025
10512	June 13	None.	None.	0.01	5.90	.0000	.0062	.39	.0250	.0000	.0636	2.2	.0025
10799	Aug. 15	Decided, milky.	Cons., rusty.	0.05	5.20	.0208	.0054	.70	.0000	.0000	.1422	1.9	.1200
11170	Oct. 11	V. slight.	Slight, fibrous.	0.05	6.70	.0000	.0020	.71	.0400	.0000	.1174	3.0	.0210
11478	Dec. 12	None.	None.	0.00	6.25	.0002	.0008	.62	.0380	.0000	.0840	3.0	.0070
Av.	....	....	....	0.03	5.96	.0036	.0038	.58	.0297	.0001	.0923	2.7	.0272

Odor of No. 10799, like tar; of the others, none.——The samples were collected from a faucet at the works of the Gossamer Rubber Company, which are located near the end of the distributing system just south of the Boston and Albany Railroad about a mile west of South Framingham and a little over two miles from the pumping station by way of the pipe line.

Microscopical Examination.

No. 10799, Miscellaneous, *Zoöglœa*, 1120.
No. 11170, Fungi, *Crenothrix*, 78. Miscellaneous, *Zoöglœa*, 6. Total, 84.
No. 11478, Diatomaceæ, *Melosira*, 3. Fungi, *Crenothrix*, 1. Infusoria, *Peridinium*, 1. Total, 5.
No organisms were found in the remaining samples.

Chemical Examination of Water from the Underdrain beneath the Sewers at Framingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
-	Jan. 14	V. slight.	Cons.	0.02	20.10	.0840	.0050	4.20	.6250	.0015	.0800	7.4	-
-	Feb. 14	V. slight.	Cons.	0.02	18.90	.0960	.0060	3.70	.6000	.0013	.0500	7.8	-
-	Mar. 14	Slight.	Slight.	0.00	18.70	.0840	.0060	3.15	.6000	.0010	.0400	7.3	-
-	Apr. 14	V. slight.	Slight.	0.01	20.30	.0960	.0040	3.65	.6750	.0010	.0800	7.5	-
-	May 18	V. slight.	Slight.	0.02	17.50	.0880	.0050	3.20	.7500	.0012	.0500	7.4	-
-	June 13	V. slight.	Slight.	0.02	21.00	.0920	.0030	4.15	.7500	.0010	.0600	7.5	-
-	July 14	V. slight.	Slight.	0.01	24.60	.0800	.0030	4.45	.6250	.0011	.0400	7.6	-
-	Aug. 14	None.	Slight.	0.02	20.40	.0720	.0020	3.95	.6000	.0010	.0600	7.5	-
-	Oct. 15	V. slight.	Slight.	0.02	24.20	.0760	.0020	4.35	.6250	.0018	.1000	7.7	-
-	Nov. 14	V. slight.	Slight.	0.02	22.70	.0760	.0030	4.00	.5400	.0025	.0800	7.1	-
-	Dec. 12	V. slight.	Slight.	0.02	19.90	.0678	.0040	3.45	.5200	.0023	.0700	6.9	-
Av.	....	....	....	0.02	20.75	.0829	.0039	3.84	.6282	.0014	.0645	7.4	-

Averages of Analyses of Previous Years.

-	1889*	-	-	0.00	19.70	.0800	.0060	3.73	.4750	.0045	-	6.6	-
-	1890	-	-	0.01	19.71	.0824	.0073	3.51	.5336	.0026	-	8.4	-
-	1891	-	-	0.01	20.44	.1029	.0045	3.51	.5333	.0019	-	8.0	-
-	1892	-	-	0.01	19.32	.0805	.0042	3.99	.6667	.0018	-	8.0	-
-	1893	-	-	0.02	20.75	.0829	.0039	3.84	.6282	.0014	.0645	7.4	-

* October.

Note to analyses of 1893: Odor, generally faintly vegetable and mouldy.——The samples were collected from the underdrain at its outlet.

The analysis of 1889 was made before sewage was admitted to the sewers. Several of the analyses made in 1890 and all of those of subsequent years were made by the city of Boston.

GARDNER.

WATER SUPPLY OF GARDNER. — GARDNER WATER COMPANY.

Chemical Examination of Water from Crystal Lake, Gardner.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9896	Jan. 18	V. slight.	V. slight.	0.03	2.90	0.90	.0006	.0116	.0098	.0018	.32	.0000	.0000	.1700	0.8
10037	Feb. 21	Slight.	V. slight.	0.05	2.45	0.85	.0012	.0116	.0096	.0020	.35	.0060	.0000	.2497	1.3
10135	Mar. 16	Slight, clayey.	Slight.	0.08	2.85	0.80	.0092	.0146	.0116	.0030	.40	.0050	.0001	.2376	0.9
10268	Apr. 19	Slight.	Slight.	0.03	2.55	0.55	.0004	.0114	.0096	.0018	.26	.0050	.0001	.1569	0.8
10397	May 16	Slight.	V. slight.	0.05	2.75	0.85	.0004	.0126	.0106	.0020	.18	.0050	.0000	.1934	0.9
10517	June 13	Distinct.	Cons.	0.05	2.95	0.95	.0000	.0172	.0126	.0046	.27	.0000	.0000	.1507	0.8
10567	June 26	Slight, white.	Slight.	0.02	2.65	1.25	.0004	.0246	.0228	.0018	.28	.0000	.0000	.1580	0.5
10662	July 14	V. slight.	Slight.	0.03	2.50	1.05	.0008	.0158	.0122	.0036	.22	.0000	.0000	.1971	0.8
10813	Aug. 15	Slight.	Slight.	0.05	2.45	0.65	.0000	.0120	.0102	.0018	.26	.0000	.0000	.1856	0.8
11016	Sept. 12	V. slight.	V. slight.	0.02	2.55	0.85	.0000	.0108	.0090	.0018	.25	.0000	.0000	.1755	0.5
11207	Oct. 17	V. slight.	V. slight.	0.03	2.85	1.00	.0000	.0114	.0104	.0010	.26	.0000	.0000	.1620	0.5
11332	Nov. 14	V. slight.	V. slight.	0.10	2.55	0.55	.0006	.0080	.0062	.0018	.26	.0020	.0000	.2282	0.8
11472	Dec. 11	Slight.	Slight.	0.04	2.70	0.65	.0010	.0108	.0086	.0022	.26	.0020	.0000	.1440	1.1
* Av.	....	....	....	0.05	2.65	0.82	.0012	.0126	.0105	.0021	.27	.0021	.0000	.1879	0.8

Averages of Analyses of Previous Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
-	1887†	-	-	0.02	2.63	0.62	.0006	.0111	-	-	.21	.0019	-	-	-
-	1888‡	-	-	0.01	2.60	0.62	.0023	.0112	-	-	.22	.0094	.0001	-	-
-	1891§	-	-	0.02	2.95	0.85	.0007	.0119	.0298	.0021	.16	.0073	.0001	0.7	-
-	1892‖	-	-	0.02	2.45	0.65	.0008	.0104	.0086	.0018	.27	.0180	.0000	1.1	-
-	1893	-	-	0.05	2.65	0.82	.0012	.0126	.0105	.0021	.27	.0021	.0000	.1879	0.8

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December. ‡ January to May. § June, three samples. ‖ March.

NOTE to analyses of 1893: Iron, .0054. Odor, generally faintly vegetable or none; in June the odor became disagreeable and oily on heating the water. —— The first five samples were collected from a faucet at the pumping station while pumping. No. 10567 was collected directly from the lake. The remaining samples were collected from a faucet in the town.

G

Microscopical Examination of Water from Crystal Lake, Gardn

[Number of organisms per cubic centimeter.]

	1892.										
	Jan.	Feb.	Mar.	Apr.	May.	June.	June.	July.	Aug.	Sept.	Oct
Day of examination,	20	23	17	20	17	14	28	15	16	14	1
Number of sample,	9896	10037	10135	10268	10397	10517	10567	10662	10813	11016	1120
PLANTS.											
Diatomaceæ,	**34**	**1**	**0**	**33**	**186**	**675**	**180**	**46**	**5**	**0**	**pr.**
Asterionella,	0	0	0	7	160	32	0	0	2	0	0
Cyclotella,	34	0	0	1	20	580	180	30	1	0	pr.
Fragilaria,	0	0	0	0	0	0	0	0	0	0	0
Melosira,	0	0	0	0	0	0	0	0	0	0	0
Synedra,	0	1	0	24	3	52	pr.	16	0	0	pr.
Tabellaria,	0	0	0	1	3	11	0	0	2	0	pr.
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**18**	**3**	**1**	**0**	**84**
Chroöcoccus,	0	0	0	0	0	0	0	0	0	0	84
Cœlosphærium,	0	0	0	0	0	0	18	3	1	0	0
Algæ,	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**	**0**	**0**
Botryococcus,	0	0	0	0	0	0	0	0	0	0	0
Protococcus,	8	0	0	0	0	0	0	0	6	0	0
Raphidium,	0	0	0	0	0	0	0	0	0	0	0
ANIMALS.											
Infusoria,	**4**	**122**	**1**	**62**	**48**	**9**	**52**	**42**	**2**	**0**	**122**
Dinobryon,	0	94	0	22	0	0	0	0	0	0	0
Dinobryon cases,	4	28	0	40	48	6	0	pr.	0	0	122
Monas,	0	0	0	0	0	1	0	pr.	0	0	0
Peridinium,	0	pr.	1	0	pr.	0	52	42	2	0	pr.
Trachelomonas,	0	0	0	0	0	2	pr.	0	pr.	0	0
Vermes,	**0**	**pr.**	**0**	**0**	**1**	**1**	**0**	**pr.**	**pr.**	**0**	**pr.**
Anurea,	0	pr.	0	0	1	0	0	pr.	0	0	pr.
Rotatorian ova,	0	0	0	0	0	1	0	0	pr.	0	0
Miscellaneous, Zoöglœa,	**0**	**8**	**22**	**0**	**8**	**60**	**2**	**22**	**2**	**32**	**2**
TOTAL,	46	131	23	95	243	745	252	113	16	32	208

GRAFTON.

Water Supply of Grafton. — Grafton Water Company.

Chemical Examination of Water from the Filter-gallery of the Grafton Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
10251	Apr. 12	None.	None.	0.0	11.85	.0004	.0012	1.58	.4500	.0000	.0255	4.2	.0010
11189	Oct. 12	None.	None.	0.0	8.35	.0000	.0008	0.97	.1500	.0000	.0405	3.5	.0025

Odor, none.——The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No. 10251. Miscellaneous, *Zoöglœa*, 2.
No. 11189. Miscellaneous, *Zoöglœa*, 21.

Water Supply of Saundersville, Grafton.

A small system of works was constructed in 1893 to supply water to the Saunders' Cotton Mills, in Saundersville, Grafton, and the houses in the vicinity of the mills. The supply is taken from springs on the northerly slope of Leland Hill in Sutton, the water of which is collected in a covered reservoir and conveyed to the village through an eight-inch cast-iron pipe. The advice of the State Board of Health relative to this source of supply may be found on page 49 of this volume. Analyses of water from the spring and from a well near the mills are given below.

Chemical Examination of Water from a Spring and a Well made during an Investigation for a Water Supply for Saundersville, Grafton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
11243	Oct. 23	None.	None.	0.02	7.60	.0048	.0018	0.23	.0280	.0000	.1292	0.5	.0000
11244	Oct. 23	None.	None.	0.00	14.30	.0000	.0000	1.57	.8000	.0009	.0076	5.1	.0080

Odor, none.——The first sample was collected from a spring on the northerly slope of Leland Hill in Sutton, near the boundary line between Sutton and Grafton. The last sample was collected from a well about three feet in diameter and ten feet in depth at the Saunders' Cotton Mills.

Microscopical Examination.

No. 11243. Diatomaceæ, *Tabellaria*, 2.
No. 11244. No organisms.

Hanson.

Chemical Examination of Water from Maquam Pond, Hanson.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10338	Apr. 29	V. slight.	Slight.	0.02	2.35	0.85	.0002	.0148	.0124	.0024	.54	.0000	.0000	.1314	0.3

Iron, none. Odor, distinctly vegetable and disagreeable, becoming faintly vegetable on heating. — The sample was collected from the pond at its northerly end, near the shore.

Reference is made to the quality of this water in a reply of the State Board of Health to the town of Whitman with regard to taking a water supply for the town from this pond and from other sources in the vicinity, which may be found on page 67 of this volume

Microscopical Examination.

Diatomaceæ, *Melosira*, 2; *Synedra*, 1; *Tabellaria*, 9. Algæ, *Ulothrix*, 1. Infusoria, *Dinobryon*, 2; *Dinobryon cases*, 32; *Peridinium*, 792. Total, 839.

Water Supply of Haverhill.

Chemical Examination of Water from Crystal Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9928	Feb. 15	Slight.	V. slight.	0.20	2.55	1.10	.0000	.0170	.0150	.0020	.27	.0000	.0000	.4222	1.8
10526	June 19	Slight.	Cons., brown.	0.40	2.80	1.10	.0008	.0218	.0160	.0058	.24	.0030	.0000	.3383	0.9
11217	Oct. 17	Slight.	Slight.	0.18	2.85	1.15	.0000	.0158	.0140	.0018	.22	.0030	.0000	.3402	0.8
Av.	....	....	....	0.26	2.73	1.12	.0003	.0182	.0150	.0032	.24	.0020	.0000	.3669	1.0

Iron, .0045. Odor of the first sample, very disagreeable, disappearing on heating; of the second sample, vegetable; of the last, very faintly vegetable, becoming stronger and grassy on heating. —— The first and last samples were collected directly from Crystal Lake; the second sample, from a faucet in the city supplied from Crystal Lake.

Microscopical Examination.

The total number of organisms per cubic centimeter found in these samples was as follows: In February, 8; in June, 311; in October, 56.

HAVERHILL.

Chemical Examination of Water from Kenoza Lake, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10030	Feb. 15	Slight.	Slight.	0.15	3.75	1.30	.0032	.0234	.0168	.0066	.50	.0030	.0000	.3322	1.7
10529	June 19	Slight.	Slight, gray.	0.05	3.45	1.10	.0006	.0206	.0172	.0034	.36	.0000	.0000	.2077	1.6
11216	Oct. 17	Slight.	Slight.	0.08	3.45	0.95	.0000	.0166	.0148	.0018	.36	.0000	.0000	.2430	1.6
Av.	....	....	....	0.09	3.55	1.12	.0013	.0202	.0163	.0039	.41	.0010	.0000	.2610	1.6

Iron, .0052. Odor, vegetable and unpleasant in the first two samples; faintly vegetable in the last. The odor diminished on heating.—— The samples were collected from the lake.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 192; in June, 66; in October, 437.

Chemical Examination of Water from Lake Saltonstall, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10029	Feb. 15	Slight.	V. slight.	0.10	4.50	1.10	.0120	.0226	.0194	.0032	.47	.0030	.0000	.3097	2.1
10527	June 19	Slight.	Slight, brown.	0.08	5.10	1.35	.0012	.0216	.0186	.0030	.65	.0030	.0000	.1809	2.2
11214	Oct. 17	Slight.	Slight.	0.10	5.70	1.85	.0020	.0174	.0154	.0020	.64	.0030	.0000	.2592	2.2
Av.	....	....	....	0.09	5.10	1.43	.0051	.0205	.0178	.0027	.59	.0030	.0000	.2499	2.2

Iron, .0067. Odor of the first sample, distinctly vegetable and unpleasant; of the second sample, faintly vegetable, becoming stronger and unpleasant on heating; of the last sample, very faintly vegetable, becoming much stronger and grassy on heating.—— The samples were collected from the lake.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 4; in June, 191; in October, 300.

HAVERHILL.

Chemical Examination of Water from Lake Pentucket, Haverhill.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1892.														
10027	Feb. 15	Slight.	Slight.	0.08	3.45	1.10	.0012	.0178	.0140	.0038	.38	.0000	.0000	.2572	1.7
10528	June 19	Slight.	Cons., brown.	0.08	3.30	1.05	.0006	.0218	.0166	.0052	.38	.0000	.0000	.1809	1.3
11215	Oct. 17	V. slight.	Slight.	0.05	3.55	1.05	.0010	.0200	.0174	.0026	.36	.0000	.0000	.2227	1.4
Av.	....	....	....	0.07	3.43	1.07	[illegible]	.0199	.0160	.0039	.37	.0000	.0000	.2203	1.5

Iron, .0048. Odor, vegetable, stronger in the second sample than in the other two. —— The samples were collected from the lake.

Microscopical Examination.

The total number of organisms per cubic centimeter found in each of these samples was as follows: in February, 36; in June, 29; in October, 82.

Water Supply of Hingham and Hull. — Hingham Water Company.

Chemical Examination of Water from Accord Pond, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1892.														
10158	Mar. 22	Slight.	Slight.	0.20	2.95	1.00	.0004	.0082	.0058	.0024	.62	.0000	.0000	.2923	0.5
10548	June 21	V. slight.	V. slight.	0.20	3.55	1.80	.0004	.0144	.0128	.0016	.58	.0030	.0001	.3239	0.2
10760	Aug. 9	V. slight.	Slight.	0.20	3.00	1.10	.0006	.0112	.0092	.0020	.65	.0050	.0000	.2646	0.6
11072	Sept. 20	V. slight.	V. slight.	0.10	2.75	0.25	.0000	.0144	.0124	.0020	.66	.0050	.0000	.2911	0.3
11516	Dec. 18	V. slight.	V. slight.	0.10	2.85	0.85	.0000	.0124	.0114	.0010	.64	.0030	.0000	.2875	0.1
Av.	....	....	....	0.16	3.02	1.00	.0003	.0121	.0103	.0018	.63	.0032	.0000	.2919	0.3

Iron, .0043. Odor of the first sample, none, becoming vegetable on standing; of the second sample, decidedly vegetable; of the third sample, faintly vegetable; of the remaining samples, none. —— Sample No. 10760 was collected from the pump well at the pumping station; the remaining samples from the pond near the surface.

HINGHAM.

Microscopical Examination of Water from Accord Pond, Hingham.

[Number of organisms per cubic centimeter.]

	1893.				
	March.	June.	August.	September.	December.
Day of examination,	24	22	10	22	20
Number of sample,	10158	10548	10760	11072	11516
PLANTS.					
Diatomaceæ,	**17**	**16**	**5**	**1,886**	**38**
Asterionella,	4	0	0	0	0
Cyclotella,	0	14	1	0	1
Melosira,	0	0	2	1,880	0
Navicula,	0	0	pr.	4	0
Synedra,	4	1	2	2	25
Tabellaria,	9	1	0	0	12
Cyanophyceæ,	**0**	**46**	**8**	**156**	**0**
Anabæna,	0	pr.	5	100	0
Anabæna spores,	0	0	0	56	0
Cœlosphærium,	0	32	0	0	0
Merismopedia,	0	14	0	0	0
Microcystis,	0	0	3	0	0
Algæ,	**0**	**4**	**38**	**10**	**0**
Nephrocytium,	0	0	0	4	0
Pediastrum,	0	0	0	3	0
Raphidium,	0	4	38	0	0
Scenedesmus,	0	0	0	3	0
Fungi, Crenothrix,	**0**	**0**	pr.	**36**	**0**
ANIMALS.					
Infusoria,	**0**	**0**	**4**	**27**	**3**
Dinobryon cases,	0	0	pr.	0	3
Monas,	0	0	0	24	0
Peridinium,	0	pr.	4	3	0
Vermes,	**0**	**0**	**0**	**4**	**0**
Anurea,	0	0	0	1	0
Polyarthra,	0	0	0	2	0
Rotifer,	0	0	0	1	0
Miscellaneous, Zoöglœa,	**0**	**0**	**26**	**0**	**2**
TOTAL,	17	66	81	2,119	43

HINGHAM.

Chemical Examination of Water from Fulling Mill Pond, Hingham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid Total.	Albuminoid Dissolved.	Albuminoid Suspended.		Nitrates.	Nitrites.		
	1893.														
10157	Mar. 22	Distinct.	Cons.	0.43	3.80	1.15	.0006	.0150	.0076	.0074	.70	.0000	.0000	.3816	1.3
10547	June 21	V. slight.	Cons.	0.05	4.80	1.40	.0000	.0048	.0024	.0024	.59	.0200	.0001	.1066	1.1
11073	Sept. 20	Decided.	Slight.	0.12	4.80	0.75	.0008	.0560	.0264	.0296	.66	.0030	.0001	.3731	1.1
11515	Dec. 18	Slight.	V. slight.	0.30	4.60	2.00	.0010	.0134	.0108	.0026	.72	.0080	0000	.4090	1.4
Av.	....	....	....	0.23	4.50	1.33	.0006	.0223	.0118	.0105	.67	.0078	0001	.3176	1.2

Iron, 0081. Odor, vegetable or none. The odor of No. 11073 became disagreeable on heating. —— The samples were collected from the pond near the surface.

Microscopical Examination of Water from Fulling Mill Pond, Hingham.

[Number of organisms per cubic centimeter.]

	1893. March.	1893. June.	1893. September.	1893. December.
Day of examination,	23	22	22	20
Number of sample,	10157	10547	11073	11515
PLANTS.				
Diatomaceæ,	**291**	**39**	**33**	**1,629**
Asterionella,	0	0	0	8
Diatoma,	0	6	0	0
Fragilaria,	0	13	0	0
Melosira,	11	4	33	21
Navicula,	pr.	6	0	0
Pinnularia,	0	3	0	0
Synedra,	276	6	0	1,600
Tabellaria,	4	1	0	0
Cyanophyceæ, Microcystis,	**0**	**0**	**44**	**0**
Algæ,	**82**	**0**	**35**	**0**
Closterium,	6	0	0	0
Nephrocytium,	0	0	3	0
Protococcus,	20	0	20	0
Raphidium,	0	0	12	0
Tetraspora,	2	0	0	0
Zoöspores,	54	0	0	0
Fungi, Crenothrix,	**1**	**1**	**0**	**0**

HINGHAM.

Microscopical Examination of Water from Fulling Mill Pond, Hingham — Concluded.

[Number of organisms per cubic centimeter.]

	1893. March.	1893. June.	1893. September.	1893. December.
ANIMALS.				
Rhizopoda,	0	0	1	4
Dactylosphærium,	0	0	0	4
Difflugia,	0	0	1	0
Infusoria,	233	0	10	8
Cryptomonas,	1	0	0	0
Dinobryon,	64	0	0	0
Dinobryon cases,	4	0	0	1
Gonium,	4	0	0	0
Monas,	1	0	1	0
Peridinium,	158	0	7	7
Synura,	1	0	0	0
Trachelomonas,	0	0	2	0
Vermes,	0	0	0	2
Anurea,	0	0	0	1
Polyarthra,	0	0	0	1
Crustacea, Cyclops,	.02	0	0	0
Miscellaneous, Zoöglœa,	66	14	60	7
TOTAL,	673	54	183	1,650

WATER SUPPLY OF HINSDALE FIRE DISTRICT, HINSDALE.

Chemical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
10393	May 15	V. slight.	Slight.	0.10	1.85	0.70	.0000	.0138	.0082	.0056	.03	.0000	.0000	.2555	0.2
10797	Aug. 14	Distinct.	Cons., yellow.	0.30	2.55	1.45	.0000	.0242	.0154	.0088	.04	.0000	.0000	.5095	0.2
11361	Nov. 21	Slight.	Cons.	0.20	3.20	2.00	.0006	.0274	.0168	.0106	.06	.0030	.0000	.6048	0.6
Av.	....	....	....	0.20	2.53	1.38	.0002	.0218	.0135	.0083	.04	.0010	.0000	.4566	0.3

Iron, .0075. Odor of the first two samples, vegetable; of the last, very disagreeable.——The samples were collected from the reservoir.

HINSDALE.

Microscopical Examination of Water from the Storage Reservoir of the Hinsdale Fire District.

[Number of organisms per cubic centimeter.]

	1893.		
	May.	August.	November.
Day of examination,	16	15	22
Number of sample,	10393	10797	11361
PLANTS.			
Diatomaceæ,	7	1,287	22
Asterionella,	0	1,280	22
Fragilaria,	6	0	0
Melosira,	0	5	0
Synedra,	1	2	0
Algæ,	2	18	5
Arthrodesmus,	0	3	0
Protococcus,	0	2	0
Raphidium,	0	8	0
Zoöspores,	2	5	5
Fungi, Crenothrix,	0	5	0
ANIMALS.			
Rhizopoda, Arcella,	1	0	0
Infusoria,	90	23	56
Peridinium,	90	20	56
Trachelomonas,	0	3	0
Vermes,	0	12	1
Anuræa,	0	7	1
Rotatorian ova,	0	5	0
Miscellaneous, Zoöglœa,	14	48	8
TOTAL,	114	1,393	92

WATER SUPPLY OF HOLBROOK.

(See *Randolph*.)

HOLYOKE.

WATER SUPPLY OF HOLYOKE.

The advice of the State Board of Health to the city of Holyoke, with regard to an additional water supply, may be found on page 19 of this volume. On pages 168 and 169 will be found analyses of samples of water collected from various sources examined in connection with the investigation for this supply.

Chemical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9903	Jan. 18	Distinct.	Slight.	0.30	5.65	1.70	.0024	.0340	.0236	.0104	.18	.0100	.0001	.4767	3.0
10146	Mar. 21	Slight.	Slight.	0.08	3.25	1.25	.0000	.0154	.0114	.0040	.13	.0000	.0000	.2160	1.4
10442	May 22	Slight.	Slight.	0.20	3.95	1.20	.0016	.0158	.0140	.0018	.11	.0000	.0000	.3562	2.1
10632	July 10	Slight.	Slight, green.	0.12	5.20	2.45	.0000	.0212	.0182	.0030	.10	.0030	.0001	.3577	2.7
11049	Sept. 19	Decided, green.	Cons.	0.18	5.55	1.70	.0000	.0426	.0244	.0182	.15	.0030	.0000	.4428	3.1
11363	Nov. 21	V. slight.	Slight.	0.20	4.40	1.45	.0008	.0216	.0180	.0036	.12	.0220	.0002	.4536	2.5
Av.	....	....	....	0.18	4.67	1.63	.0008	.0251	.0183	.0068	.13	.0063	.0001	.3838	2.5

Averages of Analyses of Previous Years.

From Brook before Reservoir was Built.

-	1887*	-	-	0.48	7.89	1.44	.0024	.0204	-	-	.18	.0126	-	-	-
-	1888	-	-	0.25	6.63	1.22	.0009	.0183	-	-	.10	.0081	.0001	-	-
-	1889†	-	-	0.14	6.72	1.02	.0006	.0134	.0092	.0042	.11	.0054	.0001	-	-

From Reservoir.

-	1890‡	-	-	0.30	6.95	1.60	.0008	.0244	.0188	.0056	.15	.0120	.0000	-	3.6
-	1891	-	-	0.41	6.34	2.05	.0125	.0311	.0253	.0058	.12	.0185	.0006	-	3.1
-	1892	-	-	0.30	5.57	1.86	.0029	.0294	.0247	.0047	.14	.0192	.0001	-	2.8
-	1893	-	-	0.18	4.67	1.63	.0008	.0251	.0183	.0068	.13	.0063	.0001	.3838	2.5

* June to December. † January to May. ‡ December.

NOTE to analyses of 1893: Iron, .0101. Odor of the first three samples, distinctly vegetable, and of the first, also disagreeable; of the last three samples, faintly vegetable or none. On heating, the odor of all samples was distinctly vegetable.——The samples were collected from the reservoir.

HOLYOKE.

Microscopical Examination of Water from Whiting Street Storage Reservoir, Holyoke.

[Number of organisms per cubic centimeter.]

	1893.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	20	23	24	13	20	22
Number of sample,	9903	10146	10442	10632	11049	11368
PLANTS.						
Diatomaceæ,	**1**	**1**	**3**	**0**	**782**	**4**
Asterionella,	0	0	0	0	720	3
Fragilaria,	0	0	0	0	62	0
Synedra,	1	1	3	0	0	1
Cyanophyceæ, Chroöcoccus,	**0**	**0**	**24**	**0**	**0**	**0**
Algæ,	**0**	**1,464**	**1,422**	**0**	**196**	**2**
Pandorina,	0	0	42	0	0	0
Pediastrum,	0	0	0	0	4	0
Protococcus,	0	0	0	0	192	2
Selenastrum,	0	0	1,380	0	0	0
Zoöspores,	0	1,464	0	0	0	0
Fungi, Crenothrix,	**0**	**0**	**3**	**1**	**0**	**0**
ANIMALS.						
Infusoria,	**168**	**3**	**0**	**1**	**62**	**4**
Cryptomonas,	164	0	0	0	0	0
Dinobryon,	0	3	0	0	0	0
Euglena,	0	0	0	0	5	0
Monas,	0	0	0	1	0	0
Peridinium,	1	pr.	0	0	5	4
Trachelomonas,	0	0	0	0	52	0
Uroglena,	3	0	0	0	0	0
Vermes, Polyarthra,	**0**	**0**	**0**	**0**	**1**	**0**
Miscellaneous, Zoöglœa,	**0**	**52**	**3**	**56**	**3**	**0**
TOTAL,	169	1,520	1,455	58	1,044	10

HOLYOKE.

Chemical Examination of Water from Wright and Ashley Ponds, Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9904	Jan. 18	Slight.	Slight.	0.08	4.85	1.20	.0036	.0158	.0078	.0080	.17	.0120	.0001	.2664	3.9
10145	Mar. 21	None.	V. slight.	0.08	4.10	1.60	.0068	.0158	.0130	.0028	.19	.0180	.0000	.2160	2.2
10441	May 22	Slight.	Slight.	0.03	4.60	0.90	.0030	.0134	.0120	.0014	.18	.0030	.0000	.1987	3.1
10631	July 10	Slight.	Slight.	0.05	4.80	0.95	.0016	.0278	.0236	.0042	.14	.0000	.0000	.2409	3.0
11048	Sept. 19	Slight.	Slight.	0.05	5.20	1.50	.0000	.0194	.0142	.0052	.15	.0070	.0000	.2132	3.1
11362	Nov. 21	V. slight.	Cons., green.	0.06	4.70	1.10	.0004	.0248	.0204	.0044	.12	.0030	.0001	.3444	3.0
Av.	....	....	....	0.06	4.71	1.21	.0026	.0195	.0152	.0043	.15	.0072	.0000	.2466	3.1

Averages of Analyses of Previous Years.

-	1887*	-	-	0.08	5.25	0.89	.0029	.0202	-	-	.13	.0016	-	-	-
-	1888	-	-	0.06	4.81	0.82	.0024	.0178	-	-	.12	.0054	.0001	-	-
-	1889	-	-	0.02	5.37	0.74	.0020	.0201	.0161	.0040	.13	.0039	.0000	-	-
-	1890	-	-	0.01	-	-	.0020	.0201	.0151	.0050	.13	.0048	.0000	-	-
-	1891†	-	-	0.01	6.10	-	.0046	.0243	.0201	.0042	.18	.0035	.0001	-	2.9
-	1892‡	-	-	0.02	5.10	1.15	.0008	.0196	.0154	.0042	.17	.0020	.0000	-	3.1
-	1893	-	-	0.06	4.71	1.21	.0026	.0195	.0152	.0043	.15	.0072	.0000	.2466	3.1

* June to December. † July and October. ‡ May.

NOTE to analyses of 1893; Iron, .0040. Odor in March and May decidedly vegetable; in the other months, none. On heating, the odor of all samples was vegetable.—— The samples were collected from Ashley Pond.

Microscopical Examination of Water from Wright and Ashley Ponds

[Number of organisms per cubic centimeter.]

	1893.				
	Jan.	March.	May.	July.	Sept
Day of examination,	20	23	24	18	2[illegible]
Number of sample,	9904	10145	10441	10631	1104[illegible]
PLANTS.					
Diatomaceæ,	**394**	**10**	**85**	**0**	**40**
Asterionella,	2	0	0	0	0
Cyclotella,	4	0	22	0	1
Diatoma,	264	0	0	0	0
Fragilaria,	6	2	16	0	15
Melosira,	14	1	19	0	14
Stephanodiscus,	0	0	0	0	0
Synedra,	92	6	20	0	4
Tabellaria,	12	1	8	0	6
Cyanophyceæ,	**6**	**0**	**0**	**0**	**26**
Anabæna,	pr.	0	0	0	24
Chroöcoccus,	6	0	0	0	0
Microcystis,	pr.	0	0	0	2
Algæ,	**18**	**0**	**0**	**0**	**13**
Chlorococcus,	pr.	0	0	0	3
Closterium,	2	0	0	0	1
Dictyosphærium,	12	0	0	0	0
Protococcus,	4	0	0	0	4
Raphidium,	0	0	0	0	5
ANIMALS.					
Rhizopoda,	**15**	**0**	**0**	**0**	**0**
Actinophrys,	15	0	0	0	0
Difflugia,	pr.	0	0	0	0
Infusoria,	**11**	**2**	**0**	**26**	**24**
Dinobryon,	6	0	0	0	0
Dinobryon cases,	pr.	2	0	0	24
Monas,	0	0	0	26	0
Peridinium,	3	pr.	0	0	0
Synura,	pr.	pr.	0	0	0
Trachelomonas,	2	0	0	0	0
Vermes,	**1**	**1**	**0**	**0**	**0**
Anurea,	1	pr.	0	0	0
Monocerca,	0	0	0	0	0
Rotatorian ova,	0	0	0	0	0
Sacculus,	0	1	0	0	0
Miscellaneous, Zoöglœa,	**92**	**110**	**0**	**100**	**16**
TOTAL,	537	123	85	126	119

HOLYOKE.

Chemical Examination of Water from Various Sources, collected during an Investigation for an Additional Water Supply for Holyoke.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10732	Aug. 3	V. slight.	V. slight.	0.10	3.65	0.95	.0000	.0022	.0016	.0006	.19	.0090	.0000	.0666	0.6
10733	Aug. 3	Slight.	Cons.	0.10	3.10	0.75	.0000	.0108	.0056	.0052	.14	.0000	.0000	.0740	1.0
10891	Aug. 25	Slight.	Slight, rusty.	1.05	5.25	2.50	.0038	.0246	.0218	.0028	.13	.0070	.0000	1.1218	1.0
10734	Aug. 4	Slight.	Slight.	0.15	6.25	1.25	.0000	.0106	.0088	.0018	.14	.0000	.0000	.1480	3.3
10735	Aug. 3	Decided.	Cons.	0.05	3.75	1.50	.0022	.0310	.0206	.0104	.12	.0000	.0005	.1554	1.7
11267	Oct. 30	V. slight.	Slight.	0.12	3.55	0.60	.0014	.0042	.0028	.0014	.14	.0030	.0000	.2479	0.6

Iron, .0059. Odor of the first sample, none; of the remaining samples, vegetable, and of Nos. 10734 and 10735, also mouldy. The odor of the first sample became faintly vegetable on heating; those of the remaining samples were unchanged. —— The first sample was collected from Munn Brook in Granville, just below the confluence of Dickinson and Tillison Brooks. The next two samples, Nos. 10733 and 10891, were collected from the Westfield Little River, the former at Horton's Bridge in Westfield, about half a mile below the mouth of Munn Brook, and the latter at a point in Russell, about five miles farther up stream. No. 10734 was collected from Bachelor's Brook at Aldrich's Mill in Granby. No. 10735 was collected from Hampton Pond, Westfield, at its outlet, just beneath the surface. No. 11267 was collected from Willimansett Brook in Chicopee.

Microscopical Examination of Water from Various Sources, collected during an Investigation for an Additional Water Supply for Holyoke.

[Number of organisms per cubic centimeter.]

	1893.					
	Aug.	Aug.	Aug.	Aug.	Aug.	Nov.
Day of examination,	5	5	29	5	5	1
Number of sample,	10732	10733	10891	10734	10735	11267
PLANTS.						
Diatomaceæ,	**1**	**25**	**5**	**4**	**84**	**1**
Asterionella,	0	0	0	0	38	0
Cocconeis,	0	0	1	0	0	0
Cocconema,	0	0	0	1	0	0
Cyclotella,	0	0	0	0	1	0
Epithemia,	0	1	0	0	0	0
Fragilaria,	0	0	2	0	0	0
Gomphonema,	0	0	0	1	0	0
Melosira,	0	4	0	0	2	0
Navicula,	0	1	0	0	0	0
Nitzschia,	0	0	0	0	1	0
Pinnularia,	0	5	1	1	0	pr.
Synedra,	1	10	1	1	6	pr.
Tabellaria,	0	4	0	0	36	1

HOLYOKE.

Microscopical Examination of Water from Various Sources, collected during an Investigation for an Additional Water Supply for Holyoke — Concluded.

[Number of organisms per cubic centimeter.]

	1893.					
	Aug.	Aug.	Aug.	Aug.	Aug.	Nov.
PLANTS — Con.						
Cyanophyceæ,	**0**	**1**	**0**	**1**	**2,083**	**0**
Anabæna,	0	0	0	0	2,080	0
Chroöcoccus,	0	0	0	1	0	0
Clathrocystis,	0	0	0	0	3	0
Oscillaria,	0	1	0	0	0	0
Algæ,	**0**	**13**	**0**	**0**	**23**	**0**
Closterium,	0	0	0	0	2	0
Conferva,	0	0	0	0	3	0
Cosmarium,	0	0	0	0	1	0
Pediastrum,	0	1	0	0	0	0
Raphidium,	0	6	0	0	10	0
Sphærozosma,	0	6	0	0	0	0
Staurastrum,	0	0	0	0	5	0
Zoöspores,	0	0	0	0	2	0
Fungi,	**0**	**116**	**13**	**13**	**0**	**81**
Beggiatoa,	0	0	1	0	0	0
Crenothrix,	0	116	12	13	0	80
Molds,	0	0	0	0	0	1
ANIMALS.						
Infusoria,	**0**	**352**	**0**	**0**	**57**	**1**
Dinobryon,	0	12	0	0	0	0
Peridinium,	0	340	0	0	56	1
Trachelomonas,	0	0	0	0	1	0
Vermes,	**0**	**0**	**0**	**0**	**3**	**0**
Anuræa,	0	0	0	0	2	0
Polyarthra,	0	0	0	0	1	0
Miscellaneous, Zoöglœa,	**2**	**40**	**54**	**4**	**32**	**60**
TOTAL,	3	547	72	22	2,282	143

WATER SUPPLY OF HUDSON.

In the early part of 1893, particularly in January and the first part of February, this supply was affected by the presence of the organism *Uroglena*, the most noticeable characteristic of which is the oily odor which it imparts to water even when present in comparatively small numbers. This organism was present in the water supplies of Norwood and Plymouth in the years 1892 and 1893, and it has been found in other water supplies in the State. A description of this organism and an account of its effect upon the taste and odor

of water may be found in the twenty-third annual report of the State Board of Health, for 1891, pages 645–658.

Chemical Examination of Water from Gates Pond, Berlin.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9858	Jan. 9	V. slight.	V. slight.	0.06	3.00	1.25	.0112	.0278	.0234	.0044	.25	.0050	.0001	-	1.1
9875	Jan. 13	Slight.	Slight.	0.05	-	-	-	-	-	-	-	-	-	-	-
9916	Jan. 23	V. slight.	Slight, earthy.	0.02	2.60	1.20	.0076	.0310	.0268	.0042	.20	.0000	.0000	.3044	0.6
9960	Feb. 8	Slight.	Slight.	0.05	2.55	0.75	.0156	.0232	.0222	.0010	.28	.0090	.0000	.2372	0.8
10169	Mar. 27	Slight.	Slight, earthy.	0.04	2.20	0.95	.0068	.0176	.0120	.0056	.16	.0250	.0001	.1971	0.3
10227	Apr. 11	Slight.	Slight.	0.05	2.30	0.75	.0080	.0140	.0116	.0024	.27	.0000	.0000	.1788	0.5
10359	May 8	Slight.	Slight.	0.03	2.30	0.60	.0044	.0098	.0086	.0012	.20	[illegible]	.0000	.1204	0.2
10422	May 22	Distinct.	Cons.	0.05	2.15	1.05	.0006	.0150	.0124	.0026	.21	.0000	.0000	.1650	0.3
10503	June 12	Slight, green.	Slight.	0.05	2.45	1.00	.0004	.0144	.0128	.0016	.26	.0000	.0000	.1842	0.4
10560	June 26	Distinct.	Slight.	0.03	2.40	0.60	.0000	.0144	.0122	.0022	.22	.0030	.0000	.1501	0.8
10657	July 13	V. slight.	V. slight.	0.04	2.50	1.10	.0000	.0120	.0096	.0024	.20	.0050	.0000	.1971	0.6
10818	Aug. 16	Distinct.	Slight.	[illegible]	2.35	0.65	.0000	.0154	.0106	.0048	.22	.0000	.0000	.1619	0.4
11044	Sept. 19	Distinct.	Slight.	0.08	2.70	1.20	.0010	.0274	.0218	.0056	.26	.0000	.0000	.2132	0.6
11178	Oct. 12	Slight.	Slight.	0.05	2.00	1.00	.0000	.0140	.0114	.0026	.25	.0000	.0000	.2025	0.6
11327	Nov. 13	Slight.	Slight.	0.05	2.25	0.95	.0010	.0166	.0132	.0034	.22	.0020	.0000	.2448	0.8
11504	Dec. 18	V. slight.	V. slight.	0.02	3.10	1.35	.0038	.0170	.0148	.0022	-	[illegible]	.0000	.2106	0.9
Av.*	....	....	....	0.05	2.45	1.01	.0040	.0178	.0146	.0032	.23	.0039	.0000	.1965	0.6

Averages of Analyses of Previous Years.

-	1887†	-	-	0.06	3.17	0.71	.0014	.0150	-	-	.21	.0054	-	-	-
-	1888	-	-	0.08	2.55	[illegible]	.0015	.0158	-	-	.19	[illegible]	.0001	-	-
-	1889	-	-	[illegible]	2.14	[illegible]	.0020	.0189	[illegible]	[illegible]	.19	.0048	.0001	-	-
-	1890	-	-	0.02	2.82	1.04	.0023	.0161	.0124	.0037	.21	.0054	.0000	-	1.2
-	1891	-	-	0.04	2.52	0.90	.0011	.0150	.0117	.0033	.20	.0074	.0000	-	0.9
-	1893	-	-	0.05	2.45	1.01	.0040	.0178	.0146	.0032	.23	[illegible]	.0000	.1965	0.6

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average. † June to December.

Note to analyses of 1893: Iron, .0040. Odor, generally vegetable or none. A faintly oily odor was detected in Nos. 9875, 9916 and 10422. On heating, a decided oily odor was developed in the samples collected between January 13 and February 8 inclusive, and in the samples collected on May 22 and in June.—The samples were collected from the pond at the surface.

HUDSON.

Microscopical Examination of Water from Gates Pond, Berlin.

[Number of organisms per cubic centimeter.]

	1893.															
	Jan.	Jan.	Jan.	Feb.	Mar.	Apr.	May.	May.	June.	June.	July.	Aug	Sept.	Oct.	Nov.	Dec.
Day of examination,	10	14	24	9	29	12	9	23	13	27	15	17	20	13	14	19
Number of sample,	9853	9875	9916	9980	10169	10227	10359	10422	10503	10560	10657	10818	11044	11178	11327	11504
PLANTS.																
Diatomaceæ, .	30	3	0	0	22	80	351	179	186	10	0	18	26	12	791	3
Asterionella, .	0	0	0	0	4	5	71	120	1	0	0	3	1	0	400	0
Fragilaria, . .	0	0	0	0	0	0	0	3	6	0	0	0	3	0	0	0
Melosira, . .	2	0	0	0	2	60	240	7	8	0	0	0	3	8	372	0
Synedra, . .	28	3	0	0	13	15	6	2	1	1	pr.	3	1	0	8	3
Tabellaria, . .	0	0	0	0	3	0	34	47	150	9	pr.	12	18	4	11	0
Cyanophyceæ,	0	0	0	0	0	0	0	0	44	21	0	134	180	1	0	0
Anabæna, . .	0	0	0	0	0	0	0	0	31	3	0	50	0	1	0	0
Cœlosphærium, .	0	0	0	0	0	0	0	0	13	0	0	0	180	0	0	0
Microcystis, .	0	0	0	0	0	0	0	0	0	18	0	84	0	0	0	0
Algæ, . . .	0	pr.	0	0	1	4	13	11	118	133	3	1	15	3	36	1
Chlorococcus, .	0	0	0	0	1	0	0	1	3	1	0	0	6	3	0	1
Pandorina, . .	0	0	0	0	0	0	0	4	5	0	0	0	0	0	0	0
Protococcus, .	0	0	0	0	0	0	12	5	94	70	2	0	5	0	35	0
Raphidium, .	0	0	0	0	0	0	0	0	10	58	0	0	3	0	0	0
Staurastrum, .	0	0	0	0	0	0	1	1	6	2	1	1	1	0	1	0
Zoöspores, . .	0	pr.	0	0	pr.	4	0	0	0	2	pr.	0	0	0	0	0
ANIMALS.																
Rhizopoda, .	pr.	pr.	pr.	0	pr.	1	0	2	0	0	0	0	0	1	2	1
Actinophrys, .	0	0	0	0	pr.	1	0	2	0	0	0	0	0	0	2	0
Difflugia, . .	pr.	pr.	pr.	0	0	0	0	0	0	0	0	0	0	1	0	1
Infusoria, .	78	153	176	48	56	10	207	174	109	159	2	64	0	9	482	542
Dinobryon, .	0	134	166	4	19	8	20	0	2	134	0	4	0	0	136	20
Dinobryon cases,	78	14	0	42	34	0	186	172	98	22	2	24	0	0	340	520
Monas, . .	pr.	0	0	0	0	0	0	0	pr.	0	0	0	0	0	2	1
Peridinium, .	0	2	0	0	3	2	1	2	5	2	pr.	36	0	8	2	0
Trachelomonas,	0	pr.	0	0	0	0	0	0	pr.	1	0	0	0	1	2	1
Uroglena, . .	0	3	10	2	0	0	0	0	0	0	0	0	0	0	0	0
Vorticella, . .	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Vermes,																
Polyarthra, .	0	pr.	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Miscellaneous, .	0	0	0	0	60	12	22	20	42	8	26	60	3	32	36	0
Acarina, . .	0	0	0	0	0	0	0	0	.02	.01	0	0	.01	.06	0	0
Zoöglœa, . .	0	0	0	0	60	12	22	20	42	8	26	60	3	32	36	0
TOTAL, . .	108	156	176	48	139	107	593	386	479	331	31	277	224	58	1,348	548

Chemical Examination of Water from Faucets in Hudson, supplied from Gates Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9654	Jan. 9	Slight.	V. slight.	0.07	2.70	0.65	.0040	.0210	.0160	.0050	.24	[illegible]	[illegible]	-	1.4
9677	Jan. 13	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-
9678	Jan. 13	-	-	0.06	-	-	-	-	-	-	-	-	-	-	-
9679	Jan. 13	-	-	0.30	-	-	-	-	-	-	-	-	-	-	-
9680	Jan. 13	-	-	0.10	-	-	-	-	-	-	-	-	-	-	-
9917	Jan. 23	V. slight.	V. slight.	0.05	2.80	0.65	.0038	.0140	.0108	.0032	.20	.0030	.0003	[illegible]	1.3
9981	Feb. 8	Slight.	Slight.	0.05	3.10	1.10	.0010	[illegible]	.0120	.0020	.26	.0070	.0001	.1409	1.4
10099	Mar. 8	Slight.	Slight.	0.20	2.90	0.90	[illegible]	.0114	.0102	.0012	.20	.0120	.0001	.1188	1.4
10100	Mar. 8	None.	V. slight.	0.05	5.60	1.60	.0012	.0108	.0082	.0026	.25	.0100	.0001	.1224	3.6
10107	Mar. 13	V. slight.	None.	0.03	2.60	0.60	[illegible]	.0122	.0102	.0020	[illegible]	.0150	.0000	.1132	1.4
10170	Mar. 27	None.	V. slight.	0.03	2.95	0.85	.0084	.0096	.0084	.0012	.19	.0200	.0000	.1277	0.9
10604	June 12	Slight.	Slight.	0.05	3.20	0.90	.0004	.0136	.0118	.0018	.24	.0030	.0000	.1273	0.6
Av.*	....	....	....	0.09	3.22	0.91	.0027	.0133	.0108	.0025	.23	[illegible]	.0001	.1338	1.5

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average.

Iron, .0977. Odor of the first sample, oily; of the others, generally faintly vegetable or none. On heating, the odors of the first four samples, and of the last one, were oily.——The samples were collected from faucets in different parts of the town.

Microscopical Examination of Water from Faucets in Hudson, supplied from Gates Pond.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Jan.	Jan.	Jan.	Jan.	Jan.	Feb.	Mar.	Mar.	Mar.	Mar.	June.
Day of examination, .	10	14	14	14	14	24	9	9	9	14	29	13
Number of sample, . .	9654	9677	9678	9679	9680	9917	9981	10099	10100	10107	10170	10604

HUDSON.

Microscopical Examination of Water from Faucets in Hudson, supplied from Gates Pond — Concluded.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Jan.	Jan.	Jan.	Jan.	Jan.	Feb.	Mar.	Mar.	Mar.	Mar.	June.
PLANTS — Con.												
Algæ,	190	57	69	75	0	6	0	0	0	0	0	34
Nephrocytium,	4	2	3	5	0	0	0	0	0	0	0	4
Protococcus,	186	54	64	68	0	6	0	0	0	0	0	3
Raphidium,	0	0	0	0	0	0	0	0	0	0	0	22
Staurastrum,	0	1	2	2	0	pr.	0	0	0	0	0	5
ANIMALS.												
Infusoria,	4	18	8	22	1	18	1	21	0	27	2	35
Dinobryon,	0	5	4	0	0	0	0	0	0	0	0	0
Dinobryon cases,	4	13	4	21	0	18	1	21	0	26	2	32
Peridinium,	0	pr.	0	1	1	0	0	0	0	1	0	3
Trachelomonas,	0	0	pr.	0	0	pr.	0	0	0	0	pr.	0
Miscellaneous, Zoöglœa,	124	16	18	3	0	40	0	3	0	36	24	24
TOTAL,	565	449	591	522	4	238	11	25	0	70	29	195

Table showing Heights of Water in Gates Pond once each Month during 1893.

[High-water mark is 14 feet.]

DATE. — 1893.	Feet.	DATE. — 1893.	Feet.
Jan. 15,	10.0	July 15,	12.75
Feb. 15,	10.6	Aug. 15,	11.8
Mar. 15,	11.4	Sept. 15,	11.3
Apr. 15,	12.4	Oct. 15,	10.9
May 15,	13.5	Nov. 15,	10.75
June 15,	13.5	Dec. 15,	10.7

Water Supply of Hull.

(See *Hingham.*)

Water Supply of Hyde Park and Milton. — Hyde Park Water Company.

The works of this company for obtaining a supply of ground water in the vicinity of the Neponset River were enlarged early in 1893, by sinking thirty-three tubular wells, located between the old systems of tubular wells and the starch factory well mentioned in the annual

HYDE PARK AND MILTON.

report of the Board for 1892. The new wells are in parallel lines on either side of a suction pipe placed approximately at right angles to the river, their distances from the river varying from sixty-four to nearly two hundred feet. The new wells are two and a half inches in diameter and of various depths, ranging from about twenty to twenty-eight feet. Twelve of the wells nearest the river have been disconnected, but the remaining wells have been in use since they were connected with the pump in the summer.

The advice of the State Board of Health to the Hyde Park Water Company, with reference to the use of water from these wells, may be found on page 20 of this volume, and analyses of water from three are given on page 176. The temperatures of the water in the wells from which these samples were collected differed considerably one from another, and were as follows: of the well nearest the river (No. 5), forty-nine degrees; of the well near the middle of the group (No. 14), forty-one degrees; of the well farthest from the river (No. 36), forty-four degrees.

Chemical Examination of Water from the Tubular Wells of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9871	Jan. 11	None.	None.	0.00	9.15	.0056	.0044	1.30	.0120	.0003	.0592	4.3	.0160
9989	Feb. 8	None.	None.	0.02	9.50	.0056	.0024	1.36	.1000	.0005	.0606	4.9	.0170
10090	Mar. 7	None.	None.	0.03	8.90	.0022	.0002	1.19	.0750	.0004	.0504	4.4	.0160
10224	Apr. 10	None.	None.	0.02	7.50	.0014	.0016	0.96	.1100	.0001	.0766	3.0	.0100
10373	May 9	None.	None.	0.01	7.25	.0012	.0012	0.91	.1100	.0001	.0876	2.9	.0050
10493	June 7	None.	None.	0.00	7.45	.0024	.0034	0.92	.0900	.0001	.0839	3.0	.0040
10643	July 11	None.	Slight, rusty.	0.04	8.50	.0030	.0044	1.10	.0900	.0000	.1095	3.5	.0125
10758	Aug. 9	None.	None.	0.02	9.20	.0054	.0048	1.33	.0900	.0003	.1232	3.9	.0040
10988	Sept. 7	Distinct.	Cons., rusty.	0.05	8.80	.0014	.0056	1.36	.0900	.0001	.1716	4.1	.0350
11137	Oct. 3	None.	None.	0.02	9.40	.0030	.0044	1.26	.0800	.0001	.1155	2.6	.0015
11318	Nov. 9	None.	V. slight.	0.03	9.20	.0034	.0030	1.44	.1200	.0001	.1360	4.0	.0025
Av...	....	....	....	0.02	8.62	.0031	.0032	1.19	.0879	.0002	.0976	3.7	.0112

HYDE PARK AND MILTON.

Chemical Examination of Water from the Tubular Wells of the Hyde Park Water Company — Concluded.

Averages of Analyses of Previous Years.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
-	1887*	-	-	0.00	6.67	.0004	.0012	0.82	.0699	-	-	-	-
-	1888	-	-	0.00	6.06	.0001	.0023	0.75	.0641	.0002	-	-	-
-	1889†	-	-	0.00	5.76	.0001	.0019	0.68	.0596	.0001	-	-	-
-	1890‡	-	-	0.02	9.35	.0006	.0023	0.88	.0550	.0002	-	4.2	-
-	1891§	-	-	0.03	9.10	.0000	.0040	0.96	.0675	.0002	-	3.6	-
-	1892‖	-	-	0.00	7.20	.0004	.0035	0.99	.0500	.0004	-	3.0	-
-	1893	-	-	0.02	8.62	.0031	.0032	1.19	.0879	.0002	.0976	3.7	.0112

* June to December. † January to May. ‡ February and August.
§ June and September. ‖ Two samples in July.

Note to analyses of 1893: Odor, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Tubular Wells of the Hyde Park Water Company.

[Number of organisms per cubic centimeter.]

	1893. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Day of examination,	13	9	8	12	10	9	18	10	9	5	11
Number of sample,	9671	9989	10090	10224	10373	10493	10643	10758	10988	11137	11318
PLANTS.											
Diatomaceæ, Synedra,	0	0	0	46	0	pr.	0	0	0	0	0
Fungi,	0	0	3	0	0	0	15	3	372	0	4
Crenothrix,	0	0	3	0	0	0	13	2	300	0	4
Molds,	0	0	0	0	0	0	2	1	72	0	0
ANIMALS.											
Infusoria, Trachelomonas,	0	0	0	0	0	pr.	0	0	1	0	0
Miscellaneous, Zoöglœa,	0	0	0	0	3	4	2	2	76	50	1
Total,	0	0	3	46	3	4	17	5	449	50	5

HYDE PARK AND MILTON.

Chemical Examination of Water from Faucets in Milton, supplied from the Works of the Hyde Park Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9939	Jan. 25	None.	None.	0.00	8.85	.0004	.0022	1.28	.0850	.0000	.0584	4.4	.0010
10050	Feb. 27	None.	None.	0.03	8.25	.0008	.0018	1.20	.0850	.0000	.0504	4.3	.0000
10158	Mar. 22	None.	V. slight.	0.00	8.10	.0000	.0020	1.11	.0600	.0000	.0504	3.6	.0000
10210	Apr. 4	None.	Slight.	0.00	7.25	.0000	.0018	0.89	.0800	.0001	.0387	2.9	.0045
10357	May 4	None.	None.	0.02	7.75	.0006	.0044	0.92	.1100	.0000	.0547	3.2	.0025
10497	June 7	None.	None.	0.00	6.90	.0004	.0010	0.96	.0800	.0000	.0469	2.9	.0050
10614	July 5	None.	None.	0.03	7.60	.0010	.0018	1.09	.0800	.0000	.0803	3.6	.0000
10768	Aug. 8	None.	None.	0.05	8.80	.0004	.0026	1.31	.0900	.0000	.0814	3.3	.0000
11047	Sept. 18	None.	None.	0.02	8.70	.0010	.0040	1.28	.0900	.0000	.1107	3.5	.0050
11220	Oct. 17	None.	None.	0.00	9.00	.0000	.0030	1.33	.0900	.0000	.0972	3.8	.0050
11374	Nov. 21	None.	None.	0.00	8.55	.0000	.0028	1.35	.1000	.0000	.1050	3.6	.0030
11514	Dec. 18	None.	None.	0.00	9.10	.0000	.0028	1.40	.0800	.0000	.1053	3.8	.0000
Av...	....	....	....	0.01	8.24	.0004	.0025	1.18	.0858	.0000	.0733	3.6	.0024

Odor, none.—The samples were collected from faucets on Adams Street, generally in the office of the Milton Water Company.

Microscopical Examination.

No. 10210, Fungi, *Crenothrix*, 8.
Nos. 10357, 10768 and 11220, Miscellaneous, *Zoöglœa*, 2.
No organisms were found in the remaining samples.

Chemical Examination of Water from Three of the New Tubular Wells added to the Works of the Hyde Park Water Company in 1893.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10455	May 29	Distinct.	Con., yellowish.	0.05	7.80	.0456	.0018	.77	.2000	.0005	.0375	1.9	.0770
10456	May 29	None.	V. slight.	0.01	4.10	.0000	.0004	.73	.0500	.0000	.0113	1.3	.0050
10457	May 29	Distinct, clayey.	Cons., clayey.	0.01	5.10	.0008	.0008	.94	.0500	.0000	.0263	1.4	.0050
Av...	....	....	....	0.02	5.67	.0155	.0010	.81	.1000	.0002	.0250	1.5	.0290

Odor, none.—The first sample was collected from well No. 5, one of the wells nearest the river and distant from it about sixty-four feet; the second sample, from well No. 14, one of the wells near the middle of the group and distant about one hundred and four feet from the river; the last sample, from well No. 36, one of the wells farthest from the river and distant from it about one hundred and ninety-six feet.

Microscopical Examination.

No. 10455, Miscellaneous, *Zoöglœa*, 144.
No. 10456, Diatomaceæ, *Fragilaria*, 10.
No. 10457, No organisms.

HYDE PARK AND MILTON.

Chemical Examination of Water from the Neponset River at Hyde Park.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9870	Jan. 11	Distinct, milky.	Cons.	1.10	9.30	2.70	.0104	.0312	.0256	.0056	1.50	.1100	.0002	.9464	2.4
9938	Feb. 8	Decided, clayey.	Cons.	0.65	6.70	2.45	.0138	.0294	.0244	.0050	0.90	.0200	.0001	.6971	2.8
10059	Mar. 7	Distinct.	Cons., dark.	1.20	7.15	2.80	.0018	.0264	.0218	.0046	0.82	.0090	.0002	1.0868	3.1
10223	Apr. 10	V. slight.	Slight.	1.00	5.15	1.45	.0002	.0192	.0166	.0026	0.58	.0030	.0001	.7665	1.6
10372	May 9	V. slight.	Slight.	1.20	4.80	1.85	.0004	.0242	.0214	.0028	0.43	.0000	.0000	1.0512	1.1
10492	June 7	Slight.	Cons., rusty.	1.70	7.80	2.40	.0192	.0322	.0278	.0044	0.91	.0050	.0003	1.0439	2.2
10642	July 11	Distinct.	Cons., rusty.	1.30	8.40	2.60	.0116	.0612	.0324	.0288	1.52	.0050	.0002	1.2848	3.0
10757	Aug. 9	Slight, rusty.	Heavy, rusty.	1.20	8.75	8.25	.0068	.0332	.0264	.0068	1.08	.0030	.0001	1.0309	2.7
10957	Sept. 7	Slight.	Slight, brown.	1.10	8.75	2.50	.0278	.0296	.0250	.0046	1.56	.0070	.0040	.7878	2.9
11136	Oct. 3	Distinct.	Cons., rusty.	0.85	9.70	2.25	.0710	.0306	.0264	.0042	2.36	.0000	.0004	.5852	2.6
11317	Nov. 9	Slight.	Cons.	1.50	8.70	8.10	.0044	.0350	.0314	.0036	1.38	.0070	.0003	1.2720	2.5
Av.	....	....	....	1.16	7.70	2.49	.0151	.0320	.0254	.0066	1.19	.0154	.0005	.9548	2.4

Averages of Analyses of Previous Years.

-	1887*	-	-	1.19	8.35	2.30	.0053	.0400	-	-	0.99	.0080	-	-	-
-	1888	-	-	1.02	6.77	2.27	.0030	.0324	-	-	0.83	.0095	.0002	-	-
-	1891†	-	-	1.48	10.34	3.45	.0190	.0510	.0413	.0097	1.16	.0065	.0003	-	3.3
-	1892‡	-	-	0.90	13.30	2.85	.0260	.0324	.0286	.0038	2.31	.0090	.0012	-	4.4
-	1893	-	-	1.16	7.70	2.49	.0151	.0320	.0254	.0066	1.19	.0154	.0005	.9548	2.4

* June to December. † August and September. ‡ July.

Note to analyses of 1893: Iron, .0304. Odor, generally decidedly vegetable and musty, sometimes disagreeable or offensive. On heating, the odors are generally stronger and more frequently disagreeable or offensive. —— The samples were collected from the river opposite the works of the Hyde Park Water Company. The river is not used as a source of water supply.

HYDE PARK AND MILTON.

Microscopical Examination of Water from the Neponset River at Hyde Park.

[Number of organisms per cubic centimeter.]

	1893.										
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
Day of examination,	13	9	8	12	10	9	13	10	9	5	11
Number of sample,	9870	9988	10089	10223	10372	10492	10642	10757	10987	11136	11317
PLANTS.											
Diatomaceæ,	**0**	**1**	**1**	**19**	**42**	**pr.**	**58**	**24**	**76**	**6**	**24**
Epithemia,	0	0	0	0	pr.	0	0	0	2	0	3
Fragilaria,	0	0	0	0	0	0	13	0	0	0	0
Melosira,	0	0	0	0	0	0	20	0	0	1	0
Pinnularia,	0	0	0	0	0	0	1	10	0	0	1
Synedra,	0	1	1	18	42	0	24	14	72	5	13
Tabellaria,	0	0	0	1	0	pr.	0	0	2	0	7
Algæ,	**0**	**0**	**pr.**	**1**	**0**	**pr.**	**4**	**18**	**4**	**2**	**0**
Closterium,	0	0	pr.	1	0	0	0	2	2	0	0
Protococcus,	0	0	0	0	0	0	0	12	0	0	0
Scenedesmus,	0	0	0	0	0	pr.	1	0	2	2	0
Spirogyra,	0	0	0	0	0	0	3	4	0	0	0
Fungi,	**822**	**0**	**268**	**158**	**0**	**960**	**440**	**1,560**	**176**	**444**	**40**
Crenothrix,	pr.	0	0	158	0	960	440	1,560	176	444	40
Fungus,	822	0	0	0	0	0	0	0	0	0	0
Leptothrix,	0	0	268	0	0	0	0	0	0	0	0
ANIMALS.											
Rhizopoda,	**0**	**0**	**0**	**0**	**pr.**	**0**	**0**	**0**	**0**	**3**	**0**
Arcella,	0	0	0	0	pr.	0	0	0	0	1	0
Difflugia,	0	0	0	0	0	0	0	0	0	2	0
Infusoria,	**3**	**3**	**0**	**1**	**1**	**2**	**5**	**8**	**2**	**1**	**3**
Dinobryon cases,	0	0	0	1	0	0	0	0	0	0	0
Euglena,	0	0	0	0	0	0	0	2	0	0	0
Monas,	0	3	0	0	0	2	3	6	1	0	1
Peridinium,	3	0	0	0	1	0	0	0	0	1	2
Trachelomonas,	0	0	0	0	0	0	2	0	1	0	0
Miscellaneous, Zoöglœa,	**650**	**276**	**406**	**76**	**0**	**820**	**1,400**	**2,480**	**100**	**70**	**180**
TOTAL,	1,475	280	675	255	43	1,582	1,907	4,090	358	526	247

IPSWICH.

Chemical Examination of Water from Dow's Brook and Egypt River, Ipswich.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
11226	Oct. 18	V. slight.	V. slight.	0.28	6.80	1.80	.0000	.0058	.0034	.0024	.78	.0240	.0000	0.2508	2.5
11225	Oct. 18	V. slight.	Slight.	1.40	8.35	2.90	.0012	.0226	.0212	.0014	.88	.0050	.0000	1.0260	2.9

No. 11226, iron, .0300; No. 11225, iron, .0150. Odor of the first sample, none, becoming faintly vegetable on heating; of the last sample, distinctly vegetable.——The first sample was collected from Dow's Brook at a point a short distance above its mouth; the last sample, from Egypt River or Bull Brook, a short distance above the mouth of Dow's Brook. The samples were collected during an investigation for a water supply for Ipswich.

Microscopical Examination.

No. 11226. Diatomaceæ, *Synedra*, 1. Fungi, *Crenothrix*, 38. Miscellaneous, *Zoöglæa*, 12. Total, 51.
No. 11225. Diatomaceæ, *Asterionella*, 1; *Tabellaria*, 2. Fungi, *Crenothrix*, 46. Miscellaneous, *Zoöglæa*, 1. Total, 50.

WATER SUPPLY OF KINGSTON.

The advice of the State Board of Health to the town of Kingston, with reference to taking an additional supply of water for the town from Jones River, may be found on page 21 of this volume.

LAKEVILLE.

Chemical Examination of Water from Long Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10560	July 12	V. slight.	V. slight	1.10	3.75	2.20	.0000	.0234	.0202	.0032	.42	.0000	.0000	.8687	0.3
10708	July 26	V. slight.	Slight.	1.00	4.50	2.25	.0000	.0182	.0162	.0020	.39	.0000	.0000	.8066	0.5
10759	Aug. 9	Slight.	Slight.	0.75	3.35	1.80	.0000	.0132	.0110	.0022	.44	.0000	.0000	.8058	0.5
10948	Aug. 31	Slight.	Slight.	0.70	3.35	1.85	.0000	.0148	.0126	.0022	.44	.0000	.0000	.7426	0.2
[illegible]	Sept. 6	V. slight.	V. slight.	0.70	3.30	1.50	.0000	.0132	.0116	.0016	.45	.0090	.0000	.6825	0.2
Av.	....	....	....	0.85	3.65	1.92	.0000	.0166	.0144	.0022	.43	.0018	.0000	.7812	0.3

Iron, .0050. Odor of Nos. 10708 and 10948, vegetable; of the remaining samples, none.——The samples were collected from the pond five feet beneath the surface, in connection with an investigation for an additional water supply for New Bedford.

Microscopical Examination.

The number of organisms per cubic centimeter found in these samples varied from eighty in the first to three in the last, and averaged forty-eight.

LAKEVILLE.

Chemical Examination of Water from Great Quittacas Pond, Lakeville.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10658	July 12	V. slight.	V. slight.	0.65	3.45	1.80	.0000	.0138	.0120	.0018	.47	.0000	.0000	.5621	0.5
10707	July 26	V. slight.	Slight.	0.60	4.05	1.80	.0006	.0156	.0128	.0028	.47	.0000	.0000	.5032	0.5
10770	Aug. 9	Distinct.	Slight.	0.50	3.60	1.75	.0000	.0140	.0122	.0018	.53	.0000	.0000	.5506	0.6
10771	Aug. 9	Distinct.	Slight.	0.60	3.25	1.60	.0020	.0124	.0098	.0026	.48	.0000	.0000	.5293	0.8
10947	Aug. 31	Slight.	Slight.	0.55	3.40	1.65	.0000	.0154	.0126	.0028	.48	.0000	.0000	.5253	0.5
10985	Sept. 6	Slight.	Slight.	0.45	3.60	1.50	.0000	.0172	.0134	.0038	.50	.0050	.0000	.4758	0.6
Av.*	....	....	....	0.55	3.62	1.70	.0001	.0152	.0126	.0026	.49	.0010	.0000	.5234	0.5

* No. 10771 was omitted in making the average.

Iron, .0021. Odor of Nos. 10707 and 10771, distinctly vegetable; of No. 10947, faintly vegetable; of the remaining samples, none. —— The samples were collected from the pond five feet beneath the surface, excepting No. 10771, which was collected 36 feet beneath the surface at a place where the total depth of the pond was 55 feet. The samples were collected in connection with an investigation for an additional water supply for New Bedford.

Microscopical Examination of Water from Great Quittacas Pond, Lakeville.

[Number of organisms per cubic centimeter.]

	1893. July.	1893. July.	1893. Aug.	1893. Aug.	1893. Sept.	1893. Sept.
Day of examination,	15	28	11	11	2	9
Number of sample,	10658	10707	10770	10771	10947	10985
PLANTS.						
Diatomaceæ,	**3**	**1**	**246**	**20**	**30**	**14**
Asterionella,	1	0	6	0	0	4
Cyclotella,	2	0	72	5	1	1
Diatoma,	0	0	0	3	0	0
Melosira,	0	0	164	10	24	0
Synedra,	pr.	1	4	1	2	0
Tabellaria,	0	0	0	1	3	9
Cyanophyceæ, Merismopedia,	**6**	**0**	**0**	**0**	**40**	**0**
Algæ,	**2**	**0**	**0**	**4**	**0**	**8**
Protococcus,	0	0	0	0	0	8
Raphidium,	2	0	0	4	0	0
ANIMALS.						
Infusoria,	**pr.**	**7**	**50**	**4**	**38**	**42**
Dinobryon,	0	0	20	0	0	0
Dinobryon cases,	0	0	9	0	0	0
Monas,	0	0	1	0	0	0
Peridinium,	0	7	20	4	38	40
Trachelomonas,	pr.	0	0	0	0	2
Vermes,	**0**	**1**	**1**	**0**	**1**	**1**
Polyarthra,	0	1	1	0	1	0
Rotifer,	0	0	0	0	0	1
Miscellaneous, Zoöglœa,	**3**	**4**	**28**	**28**	**38**	**3**
TOTAL,	14	13	325	56	147	68

WATER SUPPLY OF LAWRENCE.

As already stated in a previous portion of this report (page 3), a filter having an area of two and a half acres was constructed by the city of Lawrence during the past year, at a cost of about sixty-five thousand dollars, and since its completion in September the water supplied to the city has been filtered.

The reply of the Board to an application from the city of Lawrence for information as to the results of the filtration of its water supply, after the filter had been in use a little more than two months, may be found on page 22 of this volume.

A more complete description of the filter with a statement of the results obtained by its use will be found in a subsequent portion of this report, also additional analyses of the Lawrence water made at the Lawrence Experiment Station.

Chemical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.

[Parts per 100,000.]

Iron, .0129. Odor, vegetable and musty.——The samples were collected from the river opposite the intake of the Lawrence Water Works, about one foot beneath the surface. For a record of the quantity of water flowing in the river on dates when samples of water were collected for analysis, see page 156. For a summary of the analyses of previous years, see "Merrimack River" in the chapter on "Examination of Rivers."

LAWRENCE.

Microscopical Examination of Water from the Merrimack River above Lawrence, opposite the Intake of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, .	20	16	17	20	18	22	21	25	22	24	23	22
Number of sample, . .	9893	10019	10125	10272	10410	10543	10679	10878	11063	11236	11371	11528
PLANTS.												
Diatomaceæ, . .	6	38	51	18	83	236	278	132	27	55	9	14
Asterionella, . .	1	2	3	0	13	0	5	24	5	0	3	0
Cyclotella, . . .	1	20	0	0	2	2	0	1	0	0	0	0
Diatoma, . . .	0	0	0	0	0	0	4	0	2	2	0	0
Fragilaria, . . .	0	0	0	2	4	20	0	0	0	0	0	0
Melosira, . . .	0	2	19	7	4	12	0	0	0	8	0	12
Meridion, . . .	0	1	0	2	4	6	0	0	0	0	0	0
Navicula, . . .	0	8	3	5	14	0	0	1	0	0	0	0
Pinnularia, . .	0	0	4	0	0	0	1	1	0	0	1	0
Synedra, . . .	3	5	4	2	34	192	184	100	20	44	3	2
Tabellaria, . .	1	0	18	0	8	10	84	5	0	1	2	0
Algæ, ...	0	0	0	1	0	7	16	19	18	1	1	0
Chlorococcus, . .	0	0	0	0	0	0	0	7	0	0	0	0
Protococcus, . .	0	0	0	0	0	4	8	5	0	0	0	0
Raphidium, . .	0	0	0	0	0	0	0	4	8	0	0	0
Scenedesmus, . .	0	0	0	0	0	1	4	3	2	0	0	0
Staurogenia, . .	0	0	0	0	0	0	0	0	8	0	0	0
Zoöspores, . .	0	0	0	1	0	2	4	0	0	1	1	0
Fungi, Crenothrix, .	0	0	0	0	8	44	9	0	64	32	0	1
ANIMALS.												
Rhizopoda, Amœba, .	0	0	2	0	0	0	0	0	0	0	0	0
Infusoria, ...	1	0	0	0	2	2	37	23	4	0	0	0
Dinobryon cases, .	1	0	0	0	2	0	32	20	0	0	0	0
Euglypha, . . .	0	0	0	0	0	0	3	0	0	0	0	0
Monas, . . .	0	0	0	0	0	0	0	0	2	0	0	0
Peridinium, . .	0	0	0	0	0	1	0	1	2	0	0	0
Synura, . . .	0	0	0	0	0	1	0	1	0	0	0	0
Trachelomonas, .	0	0	0	0	0	0	2	0	0	0	0	0
Vermes, ...	0	0	0	0	0	0	6	1	0	0	0	0
Anurea, . . .	0	0	0	0	0	0	3	1	0	0	0	0
Rotatorian ova, .	0	0	0	0	0	0	3	0	0	0	0	0
Miscellaneous, Zoöglœa,	140	12	800	104	2	6	80	200	56	32	40	64
TOTAL, ...	147	50	853	123	95	295	426	375	169	120	50	79

LAWRENCE.

Chemical Examination of Water from the Force Main at the Pumping Station of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9894	Jan. 18	Distinct.	Slight.	0.42	4.00	1.40	.0054	.0166	.0148	.0018	.30	.0050	.0001	.5475	1.8
10030	Feb. 15	Distinct, clayey.	Slight, earthy.	0.48	3.60	1.40	.0006	.0216	.0184	.0032	.18	.0120	.0000	.5610	0.9
10126	Mar. 15	Distinct, clayey.	Cons., earthy.	0.40	3.25	1.20	.0052	.0240	.0122	.0118	.20	.0150	.0001	.5165	0.9
10273	Apr. 19	Slight.	Cons., earthy.	0.48	3.00	1.10	.0014	.0152	.0096	.0056	.09	.0050	.0001	.4672	0.8
10412	May 17	Distinct.	Heavy, earthy.	0.60	2.80	1.25	.0000	.0192	.0138	.0054	.12	.0100	.0001	.5329	0.8
10544	June 21	Slight.	Cons.	0.35	4.20	1.50	.0066	.0196	.0146	.0050	.17	.0030	.0002	.4424	0.9
10580	July 19	Slight.	Cons., earthy.	0.12	4.25	1.80	.0108	.0200	.0166	.0034	.24	.0050	.0003	.3182	1.7
10679	Aug. 23	Slight.	Cons., green.	0.18	4.55	1.85	.0102	.0186	.0150	.0036	.32	.0050	.0002	.4029	1.1
*11064	Sept. 20	Distinct, clayey.	Slight.	0.05	13.70	2.25	.0708	.0104	.0078	.0026	.47	.1200	.0035	.1640	8.1
11222	Oct. 17	Slight, clayey.	None.	0.18	5.75	1.40	.0014	.0080	.0074	.0006	.24	.0250	.0002	.2128	2.1
11372	Nov. 22	V. slight.	None.	0.30	6.05	1.00	.0036	.0082	.0064	.0018	.33	.0350	.0007	.4826	3.1
11529	Dec. 20	V. slight.	V. slight.	0.33	5.50	1.05	.0090	.0100	.0078	.0022	.26	.0270	.0003	.4779	2.6
Av.	....	....	....	0.35	4.27	1.36	.0049	.0164	.0124	.0040	.22	.0134	.0002	.4465	1.5

Averages of Analyses of Previous Years.

-	†1887	-	-	0.43	5.48	1.34	.0017	.0206	-	-	.22	.0140	-	-	-
-	1888	-	-	0.28	4.31	1.09	.0024	.0159	-	-	.19	.0160	.0002	-	-
-	1889	-	-	0.28	3.22	0.99	.0029	.0175	.0145	.0030	.19	.0111	.0002	-	-
-	1890	-	-	0.34	4.03	1.51	.0030	.0162	.0126	.0036	.18	.0126	.0002	-	-
-	1891	-	-	0.26	3.79	1.43	.0039	.0151	.0119	.0032	.17	.0165	.0002	-	1.2
-	1892	-	-	0.43	4.15	1.66	.0035	.0182	.0146	.0036	.19	.0137	.0001	-	1.4
-	1893	-	-	0.35	4.27	1.36	.0049	.0164	.0124	.0040	.22	.0134	.0002	.4465	1.5

* This sample was collected on the day when the new filter was first operated, and represents the first water that passed through; it is abnormal on this account, and is therefore omitted from the average.

† June to December.

Note to analyses of 1893: Iron, .0156. Odor, vegetable and musty, occasionally none. —— The samples were collected from a faucet in the check-valve just beyond the pump, and, until September, 1893, represent a mixture of water from the river and the filter-gallery, though but a small portion of the water came from the latter source. Beginning with September, the samples represent water from the river after passing through the new filter. The odor of the filtered water was vegetable but never musty.

LAWRENCE.

Chemical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9925	Jan. 18	Distinct.	Slight.	0.45	4.45	1.80	.0058	.0166	.0138	.0028	.28	.0070	.0002	.5548	1.3
10021	Feb. 15	Slight, clayey.	Slight, earthy.	0.32	4.15	1.60	.0098	.0198	.0174	.0024	.28	.0150	.0001	.4635	1.5
10127	Mar. 15	Slight, clayey.	Slight, earthy.	0.40	4.05	1.20	.0070	.0150	.0124	.0026	.25	.0150	.0000	.4869	1.3
10274	Apr. 19	V. slight.	Slight.	0.40	2.85	1.20	.0020	.0120	.0098	.0022	.11	.0050	.0001	.4234	0.6
10411	May 17	Slight.	Slight.	0.43	2.40	0.80	.0014	.0150	.0110	.0040	.12	.0180	.0001	.4562	0.8
10545	June 21	V. slight.	Slight.	0.30	3.40	1.35	.0028	.0172	.0128	.0044	.18	.0070	.0002	.4029	0.9
10681	July 19	V. slight.	V. slight.	0.10	3.75	1.75	.0094	.0150	.0134	.0016	.23	.0050	.0002	.2886	1.1
10830	Aug. 23	V. slight.	Slight.	0.18	4.50	1.60	.0132	.0170	.0124	.0046	.28	.0070	.0001	.3476	1.4
11065	Sept. 20	Slight.	Slight.	0.35	4.95	1.80	.0118	.0158	.0140	.0018	.26	.0150	.0001	.4223	2.7
11224	Oct. 17	Slight.	Slight.	0.15	5.70	1.45	.0000	.0120	.0080	.0040	.26	.0220	.0000	.2242	2.1
11373	Nov. 22	V. slight.	None.	0.30	5.05	1.20	.0012	.0094	.0078	.0016	.26	.0180	.0005	.5040	2.8
11530	Dec. 20	Slight.	Slight.	0.30	5.00	1.30	.0026	.0094	.0080	.0014	.23	.0200	.0002	.5022	2.2
Av.	....	....	....	0.31	4.19	1.42	.0048	.0145	.0117	.0028	.23	.0128	.0010	.4231	1.5

Averages of Analyses of Previous Years.

-	1887*	-	-	0.36	4.10	1.00	.0028	.0162	-	-	.19	.0151	-	-	-
-	1888	-	-	0.27	3.81	1.19	.0032	.0140	-	-	.19	.0167	.0002	-	-
-	1889	-	-	0.25	3.18	0.93	.0030	.0150	.0130	.0020	.18	.0127	.0003	-	-
-	1890	-	-	0.27	3.64	1.09	.0032	.0134	.0108	.0026	.17	.0150	.0002	-	1.6
-	1891	-	-	0.24	3.75	1.22	.0032	.0132	.0106	.0026	.18	.0184	.0002	-	1.2
-	1892	-	-	0.36	3.97	1.59	.0037	.0158	.0132	.0026	.19	.0138	.0001	-	1.3
-	1893	-	-	0.31	4.19	1.42	.0048	.0145	.0117	.0028	.23	.0128	.0010	.4231	1.5

* June to December.

NOTE to analyses of 1893; Iron, .0117. Odor, generally distinctly vegetable, frequently mouldy. —The samples were collected from a faucet at the gate-house and represent water flowing out of the reservoir. After September 20, the reservoir was supplied with filtered water, and the mouldy odor was not noticed after that date.

LAWRENCE.

Microscopical Examination of Water from the Distributing Reservoir of the Lawrence Water Works.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	20	16	17	20	18	22	21	25	21	21	23	22
Number of sample,	9895	10021	10127	10274	10411	10545	10681	10880	11065	11224	11373	11530
PLANTS.												
Diatomaceæ,	19	3	0	52	62	8	4	2	9	8	8	1
Asterionella,	0	0	0	5	3	0	0	0	0	0	0	0
Melosira,	0	2	0	0	13	0	0	0	0	0	3	0
Meridion,	1	0	0	1	4	0	0	0	0	0	pr.	0
Navicula,	3	1	0	2	3	0	0	0	0	0	0	0
Synedra,	3	0	0	44	36	8	0	0	7	5	5	0
Tabellaria,	12	0	0	0	3	0	4	2	2	3	0	1
Algæ,	0	1	0	3	9	32	128	86	134	pr.	3	0
Chlorococcus,	0	0	0	0	0	0	0	5	5	0	0	0
Closterium,	0	0	0	0	1	7	0	1	1	pr.	1	0
Protococcus,	0	0	0	0	0	24	128	80	128	0	2	0
Zoöspores,	0	1	0	3	8	1	0	0	0	0	0	0
Fungi, Crenothrix,	0	0	0	0	3	0	3	1	4	pr.	1	0
ANIMALS.												
Infusoria,	1	0	2	0	0	0	0	2	0	2	0	0
Monas,	1	0	0	0	0	0	0	0	0	2	0	0
Peridinium,	0	0	2	0	0	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	0	0	2	0	0	0	0
Miscellaneous, Zoöglœa,	156	36	148	14	60	3	28	56	108	80	0	7
TOTAL,	176	40	150	69	134	43	163	147	255	90	12	8

Volume of Water flowing in the Merrimack River at Lawrence on the Dates when Samples of Water were collected for Analysis.

DATE.	Volume flowing in the Merrimack River in Cubic Feet per Second.		DATE.	Volume flowing in the Merrimack River in Cubic Feet per Second.	
	Rate of Flow during Eleven Hours of the Day.	Rate of Flow during the Whole Twenty-four Hours.		Rate of Flow during Eleven Hours of the Day.	Rate of Flow during the Whole Twenty-four Hours.
1893.			**1893 — Con.**		
Jan. 18,	4,580	2,770	July 19,	3,230	2,230
Feb. 15,	7,290	7,560	Aug. 23,	4,100	3,332
Mar. 15,	18,770	22,160	Sept. 21,	3,920	3,000
April 19,	18,190	17,400	Oct. 23,	4,850	3,960
May 17,	22,600	21,900	Nov. 22,	3,230	2,230
June 21,	4,780	3,900	Dec. 20,	7,790	6,970

Water Supply of Leicester.

Chemical Examination of Water from the Wells of the Leicester Water Supply District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
10039	Feb. 21	Decided, clayey.	V. slight.	0.50	5.10	.0000	.0062	.19	.0070	.0007	.2347	2.6	.1175
10275	Apr. 19	Distinct, clayey.	None.	0.50	5.00	.0006	.0038	.14	.0100	.0003	.1971	1.6	.0570
10540	June 20	V. slight.	Slight.	0.18	4.20	.0000	.0024	.19	.0500	.0005	.1239	1.5	.0200
10898	Aug. 28	None.	None.	0.00	5.50	.0006	.0008	.21	.1000	.0000	.1011	2.2	.0060
11250	Oct. 24	V. slight.	None.	0.25	6.00	.0000	.0018	.19	.0550	.0000	.1444	2.2	.0330
11527	Dec. 20	None.	None.	0.25	5.70	.0000	.0044	.21	.0730	.0000	.1579	2.2	.0185
Av.	....	....	....	0.28	5.25	.0002	.0032	.19	.0492	.0003	.1598	2.1	.0420

Odor, of No. 10275, faintly musty, becoming stronger on heating; of No. 11527, faintly vegetable; of the remaining samples, none.——The first two samples were collected from a faucet supplied through 1,500 feet of two-inch wrought-iron pipe, leading from the end of a six-inch main; the remaining samples, from faucets in the village.

Microscopical Examination of Water from the Wells of the Leicester Water Supply District.

[Number of organisms per cubic centimeter.]

	1893. Feb.	1893. Apr.	1893. June.	1893. Aug.	1893. Oct.	1893. Dec.
Day of examination,	23	20	22	29	25	22
Number of sample,	10039	10275	10540	10898	11250	11527
PLANTS.						
Diatomaceæ,	**2**	**3**	**0**	**2**	**157**	**24**
Asterionella,	1	2	0	0	76	1
Cyclotella,	0	0	0	0	7	0
Synedra,	1	1	0	0	74	21
Tabellaria,	0	0	0	2	0	2
Algæ, Protococcus,	**0**	**0**	**0**	**0**	**38**	**0**
Fungi, Fungus,	**0**	**0**	**12**	**0**	**0**	**0**
ANIMALS.						
Infusoria, Peridinium,	**0**	**0**	**0**	**0**	**1**	**1**
Miscellaneous, Zoöglœa,	**32**	**4**	**14**	**3**	**0**	**1**
Total,	**34**	**7**	**26**	**5**	**194**	**26**

LEOMINSTER.

Microscopical Examination of Water from Haynes Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1893.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	24	22	23	20	20	21
Number of sample,	9909	10144	10424	10671	11054	11351
PLANTS.						
Diatomaceæ,	**4**	**12**	**1,797**	**474**	**436**	**423**
Asterionella,	0	0	96	17	10	116
Melosira,	0	0	740	196	352	112
Synedra,	0	9	1	1	4	3
Tabellaria,	4	3	960	260	70	192
Cyanophyceæ,	**52**	**1**	**1**	**296**	**312**	**34**
Anabæna,	0	0	0	28	0	0
Clathrocystis,	52	1	1	152	312	32
Cœlosphærium,	0	0	0	116	0	2
Algæ,	**0**	**0**	**5**	**149**	**12**	**106**
Arthrodesmus,	0	0	0	0	0	3
Pediastrum,	0	0	3	7	2	3
Protococcus,	0	0	0	108	10	10
Raphidium,	0	0	0	5	0	0
Scenedesmus,	0	0	pr.	20	0	88
Staurastrum,	0	0	2	9	0	2
Fungi,	**5**	**0**	**0**	**3**	**0**	**0**
Fungus,	5	0	0	0	0	0
Molds,	0	0	0	3	0	0
ANIMALS.						
Rhizopoda, Difflugia,	**0**	**14**	**0**	**0**	**0**	**0**
Infusoria,	**52**	**2**	**1**	**3**	**8**	**3**
Cryptomonas,	0	2	0	0	0	0
Dinobryon,	8	0	0	0	0	0
Peridinium,	44	0	1	1	8	3
Trachelomonas,	0	0	0	2	0	0
Vermes,	**11**	**1**	**5**	**1**	**6**	**0**
Anuræa,	0	1	5	1	4	0
Polyarthra,	11	0	pr.	0	0	0
Rotifer,	0	0	0	0	2	0
Miscellaneous, Zoöglœa,	**424**	**4**	**22**	**0**	**0**	**0**
TOTAL,	548	34	1,831	926	774	566

LEOMINSTER.

Chemical Examination of Water from Morse Reservoir, Leominster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9910	Jan. 21	V. slight.	V. slight.	0.65	4.00	1.60	.0000	.0180	.0152	.0028	.22	.0030	.0003	.6701	1.6
10143	Mar. 20	V. slight.	Slight.	0.40	2.60	1.20	.0016	.0108	.0062	.0046	.13	.0070	.0001	.3744	0.5
10425	May 22	V. slight.	Slight.	0.40	1.85	1.10	.0000	.0110	.0088	.0022	.09	.0030	.0000	.4650	0.0
10672	July 17	V. slight.	Slight.	0.10	2.30	1.35	.0020	.0200	.0164	.0036	-	.0030	.0000	.4992	0.0
11055	Sept. 19	Slight.	Slight.	0.25	2.85	1.65	.0010	.0234	.0190	.0044	.14	.0030	.0000	.4715	0.5
11350	Nov. 20	Slight.	Slight.	0.62	2.75	1.25	.0006	.0220	.0152	.0068	.24	.0000	.0001	.6132	0.3
Av.	....	....	....	0.40	2.73	1.36	.0009	.0175	.0135	.0041	.16	.0032	.0001	.5156	0.5

Iron, .0129. Odor, generally distinctly vegetable, becoming fainter on heating. —— The samples were collected from the reservoir.

This reservoir was enlarged in 1891 by the construction of a new and higher dam, increasing its depth to 23 feet and its capacity from 7,000,000 to 40,000,000 gallons. It is said that all loam and vegetable matter was removed from the land flowed by raising the dam.

Microscopical Examination of Water from Morse Reservoir, Leominster.

[Number of organisms per cubic centimeter.]

	1893.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	24	22	23	20	21	21
Number of sample,	9910	10143	10425	10672	11055	11350
PLANTS.						
Diatomaceæ,	pr.	2	148	22	28	301
Asterionella,	0	0	15	0	4	300
Cyclotella,	0	0	6	1	0	0
Synedra,	pr.	2	124	20	4	1
Tabellaria,	0	0	3	1	20	0
Algæ,	22	2	23	10	2	404
Closterium,	22	2	0	0	0	0
Protococcus,	0	0	20	4	0	400
Raphidium,	0	0	3	0	2	4
Staurastrum,	0	0	0	6	0	0
Fungi, Molds,	0	0	0	10	0	0

LEOMINSTE

Microscopical Examination of Water from Morse Reservoir, Leominster —Concluded.

[Number of organisms per cubic centimeter.]

	1893.					
	Jan.	March.	May.	July.	Sept.	Nov
ANIMALS.						
Rhizopoda, Actinophrys,	0	0	pr.	1	0	0
Infusoria,	9	pr.	588	56	0	5
Dinobryon,	8	0	0	0	0	0
Dinobryon cases,	0	0	588	56	0	0
Peridinium,	0	pr.	pr.	0	0	5
Synura,	1	0	0	0	0	0
Vermes, Rotifer,	0	0	0	0	5	0
Miscellaneous, Zoöglœa,	30	34	13	52	48	36
TOTAL,	61	38	772	151	83	746

WATER SUPPLY OF LEXINGTON. —LEXINGTON WATER COMPANY

The advice of the State Board of Health to the Lexington Wate Company, with reference to an additional water supply, may b found on page 23 of this volume.

Chemical Examination of Water from the Covered Gallery of the Lexington Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
10278	1893. Apr. 19	None.	Slight.	0.0	9.90	.0000	.0010	.87	.6000	.0002	.0547	3.2	.010

Odor, none.—The sample was collected from the covered gallery, which is located 1,540 feet toward the village from the nearest of the original wells.

Microscopical Examination.

No organisms.

LOWELL.

Chemical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9888	Jan. 17	V. slight.	V. slight.	0.35	3.80	1.15	.0054	.0156	.0132	.0024	.23	.0100	.0001	.4672	1.2
10012	Feb. 14	Distinct.	Cons.	0.40	3.45	1.40	.0012	.0210	.0166	.0044	.12	.0090	.0001	.5235	1.8
10115	Mar. 14	Slight.	Cons., earthy.	0.40	3.25	1.10	.0026	.0178	.0140	.0038	.19	.0180	.0000	.4721	0.9
10261	Apr. 18	Slight.	Cons., earthy.	0.43	2.65	1.05	.0004	.0142	.0110	.0032	.12	.0050	.0000	.4526	0.8
10407	May 16	Decided.	Cons., earthy.	0.50	3.25	1.10	.0004	.0102	.0088	.0014	.07	.0050	.0002	.5548	0.8
10536	June 20	V. slight.	Slight.	0.20	3.00	0.95	.0014	.0150	.0106	.0044	.16	.0070	.0000	.3718	1.1
10675	July 18	Slight.	Slight.	0.10	3.60	1.15	.0020	.0170	.0140	.0030	.18	.0050	.0002	.2886	0.9
10869	Aug. 22	Slight.	Slight.	0.18	3.70	1.45	.0010	.0128	.0084	.0044	.20	.0030	.0002	.3397	1.1
11045	Sept. 19	Slight.	Slight.	0.40	3.55	0.85	.0042	.0156	.0138	.0018	.18	.0090	.0001	.4387	1.3
11209	Oct. 17	Slight.	Slight.	0.30	3.25	1.25	.0050	.0114	.0084	.0030	.17	.0090	.0000	.3483	1.3
11366	Nov. 21	V. slight.	Slight.	0.30	3.75	1.15	.0032	.0128	.0106	.0022	.16	.0100	.0000	.5124	1.1
11521	Dec. 19	V. slight.	V. slight.	0.45	3.40	1.50	.0044	.0148	.0144	.0004	.22	.0100	.0001	.5548	1.3
Av.	....	....	....	0.33	3.39	1.18	.0026	.0149	.0120	.0029	.17	.0083	.0001	.4437	1.1

Iron, .0133. Odor generally distinctly mouldy or musty, and frequently also vegetable. —— The samples were collected from the river about one foot beneath the surface.

For a summary of analyses of previous years see "Merrimack River" in the chapter on Examination of Rivers, in a subsequent portion of this report.

Microscopical Examination of Water from the Merrimack River above Lowell, opposite the Intake of the Lowell Water Works.

[Number of organisms per cubic centimeter.]

	1893. Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, .	20	16	16	19	18	22	20	23	20	19	23	20
Number of sample, .	9888	10012	10115	10261	10407	10536	10675	10869	11045	11209	11366	11521
PLANTS.												
Diatomaceæ, . .	**34**	**2**	**12**	**16**	**41**	**214**	**944**	**152**	**81**	**106**	**16**	**4**
Asterionella, . .	1	0	1	0	5	0	5	0	13	14	4	0
Cyclotella, . .	0	0	0	pr.	0	0	28	0	0	1	0	1
Fragilaria, . .	0	0	2	0	7	0	165	0	0	14	0	0
Melosira, . . .	3	0	4	4	22	0	12	0	0	0	6	0
Navicula, . . .	1	0	1	3	0	1	1	0	0	0	2	0
Pinnularia, . .	0	0	0	1	0	0	1	0	4	0	0	0
Synedra, . . .	9	1	4	4	7	200	332	140	48	76	4	3
Tabellaria, . .	20	1	0	4	0	13	400	12	26	1	0	0

Water Supply of Lynn.

The advice of the State Board of Health to the city of Lynn, with reference to increasing its water supply by taking water from the Saugus River and its tributaries, may be found on pages 25–28 of this report.

Chemical Examination of Water from Breed's Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9866	Jan. 10	V. slight.	V. slight.	0.85	4.35	1.45	.0034	.0194	.0150	.0044	.62	.0070	.0001	.6320	1.7
9996	Feb. 9	V. slight.	V. slight.	0.60	3.65	1.55	.0134	.0214	.0170	.0044	.53	.0090	.0002	.4526	1.5
10093	Mar. 7	V. slight.	V. slight.	0.50	3.70	1.20	.0094	.0144	.0128	.0016	.63	.0120	.0002	.4126	1.6
10216	Apr. 6	Slight.	Slight.	0.60	3.50	1.10	.0024	.0176	.0164	.0012	.50	.0090	.0004	.4708	0.6
10367	May 8	V. slight.	V. slight.	0.48	3.35	1.15	.0012	.0150	.0130	.0020	.45	.0000	.0000	.5110	0.5
10485	June 6	Slight.	Cons.	0.60	3.55	1.55	.0022	.0174	.0142	.0032	.55	.0030	.0001	.5402	0.8
10601	July 5	Slight.	Slight.	0.45	3.55	1.40	.0010	.0262	.0228	.0034	.53	.0030	.0001	.5767	1.3
10747	Aug. 8	Distinct.	Slight.	0.60	3.10	1.10	.0006	.0212	.0182	.0030	.54	.0000	.0000	.3996	0.9
10976	Sept. 6	Slight.	Slight.	0.60	3.15	1.25	.0006	.0218	.0182	.0036	.52	.0000	.0001	.4800	0.8
11143	Oct. 4	Slight.	Slight.	0.58	3.65	2.00	.0014	.0266	.0220	.0046	.50	.0050	.0001	.4697	0.9
11300	Nov. 7	Slight.	Cons.	1.00	3.95	1.60	.0030	.0288	.0250	.0038	.62	.0070	.0003	.6120	0.6
11461	Dec. 6	Distinct.	Slight.	0.90	3.85	1.60	.0078	.0270	.0228	.0042	.56	.0100	.0001	.5655	0.8
Av.	....	....	....	0.65	3.61	1.41	.0039	.0214	.0181	.0033	.55	.0054	.0001	.5102	1.1

Averages of Analyses of Previous Years.

-	1887*	-	-	0.51	3.70	1.82	.0006	.0217	-	-	.44	.0024	-	-	-
-	1888	-	-	0.48	3.71	1.42	.0029	.0227	-	-	.45	.0053	.0001	-	-
-	1889	-	-	0.45	3.09	1.02	.0007	.0208	.0165	.0043	.41	.0035	.0001	-	-
-	1890	-	-	0.42	3.62	1.51	.0014	.0196	.0155	.0041	.41	.0052	.0001	-	1.1
-	1891	-	-	0.35	3.35	1.37	.0009	.0156	.0131	.0025	.40	.0080	.0001	-	0.8
-	1892	-	-	0.43	3.65	1.38	.0004	.0220	.0177	.0043	.49	.0055	.0000	-	1.0
-	1893	-	-	0.65	3.61	1.41	.0039	.0214	.0181	.0033	.55	.0054	.0001	.5102	1.1

* June to December.

Note to analyses of 1893; Iron, .0223. Odor, vegetable and occasionally also mouldy and unpleasant or grassy.——The samples were collected from the pond near the gate-house about one foot beneath the surface.

Microscopical Examination of Water from Breed's Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	11	8	6	10	8	7	9	6	6	[illegible]	8
Number of sample,	9866	9996	10093	10218	10367	10485	10601	10747	10976	11143	11306	11461
PLANTS.												
Diatomaceæ,	8	0	0	10	107	[illegible]	112	73	[illegible]	370	773	122
Asterionella,	0	0	0	0	0	0	0	0	36	4	93	120
Melosira,	0	0	0	0	12	0	0	0	16	6	0	0
Synedra,	0	0	0	5	56	0	4	1	0	0	0	0
Tabellaria,	8	0	0	5	37	29	108	72	76	360	680	2
Cyanophyceæ,	0	0	0	0	1	30	0	113	23	130	24	0
Anabæna,	0	0	0	0	1	30	0	96	11	130	24	0
Clathrocystis,	0	0	0	0	0	0	0	17	5	0	0	0
Merismopedia,	0	0	0	0	0	0	0	0	7	0	0	0
Algæ,	0	0	0	0	22	2	14	16	[illegible]	5	8	0
Raphidium,	0	0	0	0	0	2	0	10	8	0	6	0
Scenedesmus,	0	0	0	0	0	0	0	2	0	5	0	0
Staurastrum,	0	0	0	0	pr.	0	8	4	0	0	0	0
Tetraspora,	0	0	0	0	18	0	0	0	0	0	0	0
Zoöspores,	0	0	0	0	4	pr.	6	0	0	0	0	0
Fungi, Glaucothrix,	0	0	0	0	0	0	0	0	12	0	0	0
ANIMALS.												
Rhizopoda, Actinophrys,	1	0	0	0	2	0	0	1	0	0	13	0
Infusoria,	1	0	1	0	[illegible]	13	9	30	25	62	20	42
Dinobryon,	0	0	0	0	2	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	0	84	13	3	22	24	0	20	25
Glenodinium,	0	0	0	0	0	0	0	0	0	0	0	3
Peridinium,	1	0	1	0	2	0	6	8	1	60	0	14
Trachelomonas,	0	0	0	0	1	0	0	0	0	2	0	0
Vermes, Anuræa,	0	0	0	0	0	2	[illegible]	0	0	0	0	1
Miscellaneous, Zoöglœa,	0	0	0	[illegible]	14	94	52	320	78	38	10	2
TOTAL,	10	0	1	16	235	140	186	553	272	605	848	167

LYNN.

Chemical Examination of Water from Birch Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Sus-pended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9865	Jan. 10	Distinct.	Slight.	0.40	5.50	1.95	.0042	.0486	.0242	.0244	.62	.0070	.0001	.6400	1.9
9985	Feb. 9	Slight.	Slight.	0.48	4.55	1.55	.0156	.0276	.0230	.0046	.62	.0070	.0002	.4672	1.8
10092	Mar. 7	Slight.	Slight.	0.55	5.15	1.80	.0248	.0190	.0174	.0016	.76	.0070	.0001	.3528	1.9
10217	Apr. 6	Distinct.	Slight.	0.45	3.55	0.80	.0010	.0220	.0184	.0036	.46	.0050	.0002	.3869	0.6
10366	May 8	Slight.	Slight.	0.33	3.45	1.10	.0006	.0198	.0134	.0064	.32	.0000	.0000	.4672	0.6
10434	June 6	Slight.	Slight.	0.50	3.50	1.30	.0004	.0206	.0162	.0044	.51	.0030	.0001	.4270	0.6
10600	July 5	Decided, green.	Slight.	0.40	4.15	1.75	.0010	.0334	.0212	.0122	.44	.0000	.0000	.4453	1.1
10746	Aug. 8	Slight.	Slight, green.	0.60	3.65	1.65	.0026	.0212	.0186	.0026	.46	.0000	.0000	.4033	0.5
10977	Sept. 6	Distinct, green.	Cons., brown.	0.80	3.55	1.20	.0012	.0348	.0212	.0136	.46	.0000	.0000	.5480	0.8
11142	Oct. 4	Slight.	Slight.	1.30	4.00	1.85	.0018	.0354	.0250	.0104	.50	.0070	.0001	.6006	0.8
11302	Nov. 7	Slight.	Slight.	1.90	4.95	2.60	.0008	.0354	.0322	.0032	.52	.0150	.0003	.8280	0.8
11460	Dec. 6	Distinct.	Slight.	1.30	4.55	1.95	.0078	.0414	.0308	.0106	.50	.0200	.0001	.7761	0.9
Av.	....	....	....	0.75	4.21	1.63	.0052	.0299	.0218	.0081	.51	.0059	.0001	.5285	1.0

Averages of Analyses of Previous Years.

-	1887*	-	-	0.57	4.02	1.61	.0016	.0289	-	-	.43	.0044	-	-	-
-	1888	-	-	0.33	3.48	1.40	.0026	.0287	-	-	.45	.0082	.0001	-	-
-	1889	-	-	0.23	2.96	1.14	.0014	.0236	.0190	.0046	.41	.0048	.0001	-	-
-	1890	-	-	0.36	3.57	1.35	.0013	.0227	.0179	.0048	.42	.0088	.0001	-	1.0
-	1891	-	-	0.42	3.26	1.30	.0005	.0241	.0183	.0058	.40	.0065	.0001	-	0.7
-	1892	-	-	0.48	3.73	1.56	.0016	.0299	.0227	.0072	.47	.0092	.0001	-	1.0
-	1893	-	-	0.75	4.21	1.63	.0052	.0299	.0218	.0081	.51	.0059	.0001	.5285	1.0

* June to December.

NOTE to analyses of 1893; Iron, .0258. Odor, generally vegetable, frequently unpleasant; on heating the odor is stronger and frequently also grassy.——The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

L

Chemical Examination of Water from Walden Pond, Lynn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen C
								Albuminoid.						
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1893.													
9868	Jan. 10	Distinct, green.	Heavy, green.	1.10	5.35	3.15	.0006	.0736	.0434	.0302	.51	.0150	.0004	1.2
9882	Jan. 13	Distinct.	Cons.	1.10	-	-	-	-	-	-	-	-	-	-
9997	Feb. 9	Slight.	Slight.	1.10	5.65	2.90	.0376	.0530	.0484	.0046	.50	.0090	.0001	.9
10094	Mar. 7	Slight.	V. slight.	1.35	4.50	2.75	.0052	.0178	.0162	.0016	.50	.0080	.0001	1.1
10154	Mar. 22	Distinct.	Cons.	0.80	3.15	1.55	.0076	.0148	.0144	.0004	.38	.0000	.0000	.64
10220	Apr. 6	Distinct.	Slight.	0.90	3.10	1.30	.0142	.0386	.0242	.0144	.38	.0050	.0003	.55
10369	May 8	Slight.	Cons.	0.70	2.80	1.25	.0012	.0276	.0202	.0074	.36	.0050	.0000	.56
10487	June 6	V. slight.	Slight.	1.10	3.45	1.95	.0110	.0378	.0238	.0140	.44	.0100	.0002	.69
10602	July 5	Decided, green.	Cons., brown.	1.25	4.60	2.45	.0060	.0488	.0294	.0194	.39	.0030	.0000	.83
10749	Aug. 8	Decided, green.	Cons., green.	1.10	4.95	3.00	.0000	.0880	.0374	.0506	.44	.0000	.0001	.72
10978	Sept. 6	Decided, green.	Cons., rusty.	0.70	4.55	2.45	.0000	.0646	.0338	.0308	.44	.0050	.0001	.73
11145	Oct. 4	Distinct.	Cons.	0.50	4.75	3.25	.0016	.0508	.0306	.0202	.44	.0030	.0000	.66
11305	Nov. 7	Distinct.	Cons., green.	0.70	4.50	2.55	.0000	.0500	.0408	.0092	.46	.0030	.0002	.776
11463	Dec. 6	Distinct.	Slight, green.	0.70	4.40	2.65	.0014	.0456	.0394	.0062	.48	.0000	.0000	.760
Av.*	....	....	....	0.92	4.33	2.40	.0066	.0470	.0309	.0161	.44	.0047	.0001	.795

Averages of Analyses of Previous Years.

-	1890	-	-	1.06	4.98	2.53	.0292	.0432	.0351	.0081	.34	.0057	.0001	-
-	1891	-	-	1.21	4.32	2.20	.0058	.0615	.0403	.0212	.34	.0091	.0001	-
-	1892	-	-	0.90	4.81	2.50	.0094	.0626	.0383	.0243	.41	.0116	.0001	-
-	1893	-	-	0.92	4.33	2.40	.0066	.0470	.0309	.0161	.44	.0047	.0001	.7954

* Where more than one sample was collected in a month the mean analysis for that month has t used in making the average given at the bottom of the table.

Note to analyses of 1893; Iron, .0234. Odor, distinctly vegetable and generally also unpleasant; heating, the odor is somewhat stronger.——The samples were collected from the pond near the g house, one foot beneath the surface.

LYNN.

Microscopical Examination of Water from Walden Pond, Lynn.

[Number of organisms per cubic centimeter.]

	1893.													
	Jan.	Jan.	Feb.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	17	11	8	24	8	10	8	7	9	8	6	10	8
Number of sample,	9868	9882	9997	10094	10154	10220	10369	10487	10602	10749	10978	11145	11305	11463
PLANTS.														
Diatomaceæ,	0	0	0	0	0	28	235	0	2	0	5	56	0	26
Asterionella,	0	0	0	0	0	0	128	0	2	0	0	39	0	24
Melosira,	0	0	0	0	0	0	0	0	0	0	0	16	0	0
Synedra,	0	0	0	0	0	4	3	0	0	0	0	0	0	2
Tabellaria,	0	0	0	0	0	24	104	0	0	0	5	1	0	0
Cyanophyceæ,	3	0	5	1	8	6	0	56	600	490	380	146	0	0
Anabæna,	0	0	0	0	0	3	0	42	36	420	0	64	0	0
Anabæna spores,	0	0	0	0	0	0	0	0	44	0	0	0	0	0
Clathrocystis,	3	0	5	1	8	3	0	14	520	70	380	82	0	0
Algæ,	2	0	0	0	0	81	28	144	4	5	7	2	0	0
Chlorococcus,	0	0	0	0	0	0	pr.	74	0	0	0	0	0	0
Closterium,	2	0	0	0	0	7	1	24	1	0	0	0	0	0
Pediastrum,	0	0	0	0	0	0	1	0	0	5	1	0	0	0
Staurastrum,	0	0	0	0	0	pr.	6	46	3	0	6	2	0	0
Zoöspores,	0	0	0	0	0	74	20	0	0	0	0	0	0	0
Fungi, Crenothrix,	0	0	0	0	0	7	2	1	0	0	3	6	240	1
ANIMALS.														
Infusoria,	1,113	0	9	6	0	47	29	0	0	20	0	7	0	16
Bursaria,	0	*	0	0	0	0	0	0	0	0	0	0	0	1
Cryptomonas,	1,084	0	0	6	0	2	0	0	0	0	0	0	0	0
Dinobryon,	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	0	0	0	22	0	0	0	0	0	0	13
Disintegrated infusoria,	0	0	0	0	0	14	0	0	0	0	0	0	0	0
Euglena,	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Peridinium,	28	0	9	0	0	30	6	0	0	20	0	1	0	0
Trachelomonas,	1	0	0	0	0	0	0	0	0	0	0	6	0	0
Vermes,	1	0	0	3	0	1	0	pr.	0	0	0	0	0	0
Anurea,	0	0	0	2	0	0	0	pr.	0	0	0	0	0	0
Polyarthra,	1	0	0	1	0	1	0	0	0	0	0	0	0	0
Crustacea, Cyclops,	.08	0	.04	0	0	0	0	.03	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	0	0	0	0	0	930	34	112	44	15	48	166	32	0
TOTAL,	1,119	*	14	10	8	1,100	328	313	650	530	443	383	272	43

* Bursaria extremely abundant.

Chemical Examination of Water from Glen Lewis Pond, Lynn.

[Parts per 100,000.]

Averages of Analyses of Previous Years.

-	1890	-	-	0.76	4.84	2.21	.0412	.0445	.0327	.0118	.36	.0063	.0001	-	2.0
-	1891	-	-	0.63	3.90	1.75	.0328	.0484	.0324	.0160	.34	.0124	.0002	-	0.6
-	1892	-	-	0.62	3.95	1.95	.0127	.0475	.0332	.0143	.40	.0193	.0002	-	0.6
-	1893	-	-	0.64	3.31	2.14	.0112	.0729	.0329	.0400	.42	.0040	.0002	.0046	0.6

NOTE to analyses of 1893; Iron, .0169. Odor, generally distinctly vegetable and frequently unpleasant, on heating, the odor is much stronger and is sometimes very disagreeable.——The samples were collected from the pond near the gate-house, one foot beneath the surface.

LY

Table showing Depth of Water in Feet in the Ponds and Storage Reservoirs the Lynn Water Works on the Dates when Samples of Water were colle for Analysis during the Year 1893.

	Breed's Pond. High Water, *21.50 Feet.	Birch Pond. High Water, *21.50 Feet.	Walden Pond. High Water, 17.00 Feet.	Glen Lewis P High Wate 17.00 Feet
Jan. 10,	11.96	7.54	14.50	8.54
Feb. 9,	12.75	8.00	12.83	6.37
Mar. 7,	15.13	9.67	12.88	6.40
April 6,	20.25	17.08	14.50	10.67
May 8,	21.75	22.50	16.17	15.17
June 6,	21.08	22.58	16.83	17.33
July 5,	19.83	19.71	16.67	17.25
Aug. 8,	17.75	15.58	16.25	17.25
Sept. 6,	16.71	11.88	16.00	17.13
Oct. 4,	14.50	8.92	16.58	17.00
Nov. 7,	10.50	7.00	15.50	17.08
Dec. 6,	10.67	6.67	16.92	11.13

* The water in these ponds is sometimes raised somewhat above ordinary high water in the latt part of the spring in order to increase the storage.

Water Supply of Malden, Medford and Melrose.

On Feb. 9, 1893, when Spot Pond had reached a much lowe level than ever before, the State Board of Health addressed communication to the Water Boards of Malden, Medford an Melrose, urging the necessity of taking immediate measures fo increasing the amount of water in the pond, and giving estimate of the probable condition of the pond on Jan. 1, 1894, unde minimum, average and maximum conditions of rainfall during the remaining eleven months of the year.

The estimates of the amount of water which would enter the pond were based upon the yield per square mile of watershed, as deduced from measurements of the flow from the Sudbury River watershed during the past eighteen years, and the influence of the evaporation from the surface of the pond was also included. The draft from the pond was reckoned at 600,000 gallons per day for each community, which was about the rate at which water was being drawn from the pond a few months before. It was urged, however, in the communication, that this draft from the pond

MALDEN, MEDFORD AND MELROSE.

should be reduced by taking as much water as possible from supplementary sources.

It is gratifying to note that at the end of the year the quantity drawn from the pond was 119,000,000 gallons (equivalent to a depth of about 2.5 feet on the pond) less than it would have been if each of the three communities had continued to draw at the rate of 600,000 gallons per day; the diminished draft being due in part to a restriction of use and waste, but still more to the amount of water supplied from supplementary sources throughout the whole year at Malden, and during the latter part of the year at Medford and Melrose.

The yield of the Sudbury River watershed during the eleven months from Feb. 1, 1893, to the end of the year was very nearly the same as the average for those months during the preceding eighteen years, and with average conditions the prediction contained in the communication indicated that the quantity of water in the pond would be increased 46,000,000 gallons on Jan. 1, 1894, upon the assumption that 600,000 gallons per day would be drawn by each community. To this quantity should be added the 119,000,000 gallons due to the smaller draft from the pond, making 165,000,000 gallons as the increased amount that should be in the pond on this date, according to the prediction.

By consulting the records of the height of the pond, it was found that it contained 184,000,000 gallons more on Jan. 1, 1894, than on Feb. 1, 1893, which showed a difference between the predicted yield in an average year and the actual yield of only 19,000,000 gallons; by taking into account the slight variation in the yield of the Sudbury River during these eleven months from the yield during the same months in an average year a still closer agreement was found. This is a further confirmation of what has already been well established, namely, that the capacity of this source may properly be reckoned upon the basis of the size of its watershed, assuming that the flow from each square mile is the same as from the watershed of Sudbury River.

MALDEN, MEDFORD AND MELROSE.

Chemical Examination of Water from Spot Pond, Stoneham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9850	Jan. 3	Slight, clayey.	Slight.	0.10	4.90	1.40	.0114	.0178	.0162	.0016	.52	.0150	.0001	.2320	2.6
9952	Feb. 7	Distinct.	Slight.	0.48	4.50	1.35	.0210	.0142	.0126	.0016	.36	.0100	.0005	.2044	1.9
10063	Mar. 6	Distinct.	V. slight.	0.70	7.05	2.05	.0210	.0188	.0164	.0024	.58	.0200	.0002	.5688	3.0
10214	Apr. 4	Distinct.	Cons.	0.35	5.45	1.35	.0140	.0176	.0152	.0024	.46	.0300	.0010	.3504	2.5
10354	May 2	Slight.	Slight.	0.38	5.80	1.65	.0072	.0186	.0150	.0036	.44	.0150	.0006	.3321	2.2
10477	June 5	Distinct.	Slight, brown.	0.35	5.05	1.95	.0052	.0232	.0180	.0052	.49	.0100	.0003	.5025	1.9
10611	July 5	Decided, green.	Slight, yellow.	0.15	5.85	1.85	.0000	.0192	.0134	.0058	.50	.0000	.0000	.3796	2.8
10742	Aug. 7	Decided, green.	Cons.	0.15	5.75	1.70	.0000	.0228	.0158	.0070	.49	.0030	.0000	.3034	3.5
10972	Sept. 5	Distinct, green.	Slight, brown.	0.18	6.00	1.90	.0012	.0278	.0212	.0066	.54	.0000	.0000	.4240	2.2
11148	Oct. 4	Slight.	Cons., dark.	0.18	6.20	2.20	.0076	.0214	.0198	.0016	.52	.0030	.0002	.3234	2.3
11458	Dec. 5	Slight.	Slight, dark.	0.13	6.15	1.40	.0048	.0158	.0150	.0008	.51	.0100	.0000	.2145	2.2
Av.	....	....	....	0.29	5.70	1.71	.0085	.0197	.0162	.0035	.49	.0105	.0003	.3486	2.4

Averages of Analyses of Previous Years.

-	1887*	-	-	0.25	4.83	1.24	.0004	.0207	-	-	.46	.0025	-	-	-
-	1888	-	-	0.22	3.98	1.24	.0007	.0225	-	-	.44	.0054	.0001	-	-
-	1889	-	-	0.26	3.54	1.17	.0017	.0236	.0198	.0038	.44	.0053	.0002	-	-
-	1890	-	-	0.24	3.96	1.24	.0019	.0220	.0180	.0040	.42	.0069	.0001	-	1.7
-	1891	-	-	0.21	3.70	1.27	.0008	.0183	.0161	.0022	.43	.0082	.0001	-	1.4
-	1892	-	-	0.17	4.28	1.30	.0035	.0198	.0157	.0041	.50	.0081	.0001	-	1.7
-	1893	-	-	0.29	5.70	1.71	.0085	.0197	.0162	.0035	.49	.0105	.0003	.3486	2.4

* May to December.

NOTE to analyses of 1893: Iron, .0260. Odor, faintly vegetable and occasionally unpleasant; on heating, the odor is generally stronger; in July it was oily, in August and September, fishy, and in other months frequently grassy or mouldy.—The samples were collected either from a faucet in the pumping station of the Malden Water Works or from the pond near by.

The averages of analyses for the years 1892 and 1893 when compared with the averages of previous years indicate a change in the character of the water, which is doubtless due to the fact that during these two years the surface of the water in the pond remained very much below high water mark.

MALDEN, MEDFORD AND MELROSE.

Microscopical Examination of Water from Spot Pond, Stoneham.

[Number of organisms per cubic centimeter.]

	1893.										
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
Day of examination,	5	9	8	8	5	6	8	9	8	7	8
Number of sample,	9850	9982	10083	10214	10354	10477	10611	10742	10972	11148	11458
PLANTS.											
Diatomaceæ,	62	3	1	28	416	792	312	315	106	161	21
Asterionella,	3	0	0	1	9	0	0	0	0	3	13
Cyclotella,	3	0	0	5	1	640	140	40	28	0	6
Fragilaria,	0	0	0	2	10	0	0	0	0	0	0
Melosira,	2	0	0	6	192	40	32	39	71	130	0
Synedra,	0	1	pr.	10	50	0	36	172	3	8	0
Tabellaria,	54	2	1	4	154	112	104	64	4	20	2
Cyanophyceæ, Anabæna,	0	0	0	0	0	10	132	208	15	0	0
Algæ,	2,059	0	0	0	481	247	6	23	30	8	0
Chlorococcus,	0	0	0	0	0	0	0	0	0	8	0
Closterium,	0	0	0	0	0	0	0	1	20	0	0
Protococcus,	2,056	0	0	0	480	244	0	6	0	0	0
Raphidium,	0	0	0	0	0	0	0	7	0	0	0
Staurastrum,	3	0	0	0	1	3	6	9	10	pr.	0
ANIMALS.											
Rhizopoda, Actinophrys,	3	0	0	0	0	0	0	1	0	0	13
Infusoria,	4	pr.	1	68	67	12	4	77	71	20	1
Dinobryon,	0	0	0	0	2	3	0	0	0	0	0
Dinobryon cases,	0	0	0	0	64	5	0	0	64	20	0
Peridinium,	4	pr.	0	0	0	0	4	76	6	0	1
Synura,	0	0	0	60	0	0	0	0	0	0	0
Trachelomonas,	0	0	1	8	1	4	0	1	1	pr.	0
Miscellaneous, Zoöglœa,	2	102	78	140	26	19	244	420	56	56	40
TOTAL,	2,130	105	80	236	990	1,080	698	1,044	278	245	75

Table showing Heights of Water in Spot Pond on the Dates when Samples of Water were collected for Analysis.

Date.	Distance below High Water Mark.	Date.	Distance below High Water Mark.
1893.	Feet.	1893.	Feet.
Jan. 3,	10.81	July 5,	4.56
Feb. 8,	11.42	Aug. 7,	5.87
Mar. 6,	10.71	Sept. 5,	6.75
April 4,	6.81	Oct. 4,	8.04
May 2,	5.56	Dec. 5,	8.75
June 5,	3.67		

WATER SUPPLY OF MALDEN.

Chemical Examination of Water from Tubular Wells at Webster P Meadows), Malden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		C
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.	
	1893.										
9849	Jan. 3	None.	V. slight.	0.0	22.35	.0000	.0018	2.20	.4750	.0000	.C
9963	Feb. 7	None.	None.	0.0	23.90	.0000	.0016	2.52	.5000	.0000	.0
10084	Mar. 6	None.	None.	0.0	24.70	.0000	.0002	2.68	.4500	.0000	.0
10215	Apr. 4	None.	None.	0.0	25.55	.0000	.0012	2.40	.4800	.0001	.0
10355	May 2	None.	None.	0.0	24.50	.0002	.0032	2.35	.5000	.0001	.0
10478	June 5	None.	None.	0.0	24.60	.0000	.0002	2.83	.4750	.0000	.0
10612	July 5	None.	None.	0.0	25.20	.0000	.0006	2.62	.5000	.0000	.0
10743	Aug. 7	None.	None.	0.0	23.00	.0000	.0016	2.56	.5000	.0000	.0
10973	Sept. 5	None.	None.	0.0	22.70	.0010	.0000	2.33	.5000	.0001	.0
11149	Oct. 4	None.	None.	0.0	22.60	.0000	.0002	2.37	.5000	.0000	.0
11459	Dec. 5	None.	Slight.	0.0	21.80	.0000	.0018	2.45	.4250	.0000	.01
Av.	....	....	....	0.0	23.72	.0001	.0011	2.48	.4823	.0000	.01

Averages of Analyses of Previous Years.

-	1887*	-	-	0.0	17.08	.0000	.0008	2.20	.4050	-	-
-	1888	-	-	0.0	17.45	.0000	.0003	2.80	.5061	-	-
-	1889†	-	-	0.0	16.95	.0001	.0031	1.75	.5500	.0001	-
-	1890	-	-	0.0	18.19	.0002	.0014	2.30	.4904	.0001	-
-	1891	-	-	0.0	20.83	.0001	.0007	2.23	.5146	.0001	-
-	1892	-	-	0.0	23.00	.0000	.0005	2.36	.5129	.0000	-
-	1893	-	-	0.0	23.72	.0001	.0011	2.48	.4823	.0000	.018

* Three samples in November and December. † June and October.

NOTE to analyses of 1893; Odor, none.——The samples were collected from a faucet i ing station, while pumping, with the exception of No. 10612, which was collected fron fountain.

Water Supply of Marblehead.

The works from which the water supply of Marblehead is drawn were enlarged in 1892 by the addition of a group of five tubular wells situated about 800 feet south-east of the pumping station. The depth of the wells varies from 25 to 53 feet. From April until November, 1893, water from these wells was pumped, by means of an auxiliary pump, into the large collecting well near the pumping station. In 1893 a further addition to the works for obtaining a supply of ground water was made by the construction of a small collecting well about eight feet in depth, near a small pond, and a short distance from the tubular wells just described. This well was completed about Nov. 1, 1893, and has been connected with the large collecting well by a siphon.

The driven-well system in the marsh near Loring Avenue has been reconstructed, and during 1893 water has been drawn, when necessary, from 39 tubular wells in this vicinity. The water of these wells is affected by their proximity to the sea, and the large amount of chlorine present at times in the water supplied to the town is due chiefly to the use of water from this source.

The large collecting well constructed in 1890 continues to be the chief source of supply, and at times furnishes all of the water used by the town.

Chemical Examination of Water from the Large Collecting Well of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
11091	Sept. 25	Distinct.	Slight.	0.10	15.40	.0030	.0004	2.41	.0700	.0001	.0697	8.0	.1200
11165	Oct. 10	Distinct, milky.	None.	0.10	15.80	.0004	.0012	2.93	.0680	.0001	.0269	7.7	.0450
11470	Dec. 10	Distinct, milky.	None.	0.10	16.10	.0014	.0010	3.00	.1000	.0010	.0360	8.9	.0400
Av.	....	....	....	0.10	15.77	.0016	.0009	2.78	.0793	.0004	.0442	8.2	.0683

Odor, none.——The samples were collected either directly from the well or from a faucet at the pumping station while pumping from the well.

All of the waters in this and the two following tables contain iron in considerable amount, which oxidizes on exposure to the air, making the water somewhat turbid and colored.

Microscopical Examination.

No. 11091. Miscellaneous, *Amorphous matter*, 200.
No. 11165. Miscellaneous, *Zoöglœa*, 17.
No. 11470. No organisms.

MARBLEHEAD.

Chemical Examination of Water from the Wells of the Marblehead Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9872	Jan. 12	None.	Slight.	0.00	27.50	.0020	.0010	8.69	.0800	.0000	-	12.4	.0160
9992	Feb. 8	Distinct, clayey.	Slight.	0.03	47.70	.0010	.0024	17.00	.0750	.0000	.0365	19.6	.0220
10108	Mar. 13	None.	V. slight.	0.02	29.70	.0000	.0000	9.70	.0550	.0001	.0577	13.6	.0100
10246	Apr. 12	V. slight, clayey.	V. slight.	0.03	16.20	.0028	.0020	2.82	.1000	.0000	.0255	2.8	.0030
10375	May 10	None.	None.	0.00	16.00	.0000	.0012	3.04	.1000	.0001	.0292	7.1	.0060
10498	June 8	V. slight.	None.	0.04	15.50	.0000	.0006	2.06	.0650	.0000	.0000	6.7	.0120
10615	July 7	Slight, clayey.	Slight.	0.02	13.90	.0008	.0004	1.98	.0650	.0000	.0146	6.9	.0100
10790	Aug. 14	Slight, clayey.	V. slight.	0.01	23.00	.0000	.0004	5.14	.0400	.0000	.0181	8.4	.0090
10998	Sept. 11	Distinct, clayey.	V. slight.	0.10	16.30	.0002	.0014	2.19	.0700	.0000	.0000	7.4	.0150
11344	Nov. 16	Slight.	V. slight.	0.00	16.60	.0000	.0006	3.12	.1400	.0000	.0747	9.0	.0120
Av.	....	....	....	0.03	22.24	.0007	.0010	5.57	.0790	.0000	.0285	9.4	.0115

Odor, none; occasionally an earthy odor is developed on heating.—The samples were collected from a faucet in the town, and represent a mixture of water drawn from the various sources of supply.

Microscopical Examination.

A very few *Zoöglœa* were found in March, April and May. In the remaining months the water contained no organisms.

WATER SUPPLY OF MARLBOROUGH.

At the beginning of 1893, the new works to furnish an additional supply of water for the city of Marlborough from Millham Brook were nearly completed, and they were finished in season to permit the pumping of 38,000,000 gallons of water (nearly a quarter of the total amount consumed by the city in 1892) during the spring, when the flow in the brook was large. Of this amount 20,000,000 gallons were pumped directly into the distributing reservoir and the remainder into Lake Williams, which, at the beginning of the year, was at a much lower level than ever before. During the month of April the city was supplied wholly with water from Millham Brook.

The additional water works at present consist of a very small reservoir on Millham Brook, a pumping station near the reservoir, and a force main from which water can be discharged either into Lake Williams or, by means of a connection with the original force main, into the distributing reservoir.

MARLI

Microscopical Examination of Water from Lake Williams, Marlb

[Number of organisms per cubic centimeter.]

	1893.		
	March.	July.	September.
Day of examination,	31	3	30
Number of sample,	10191	10582	11105
PLANTS.			
Diatomaceæ,	2	55	8
Asterionella,	0	3	6
Fragilaria,	0	6	0
Tabellaria,	2	46	2
Cyanophyceæ, Cœlosphærium,	0	3	0
Algæ,	35	124	0
Chlorococcus,	8	0	0
Protococcus,	0	124	0
Zoöspores,	27	pr.	0
ANIMALS.			
Infusoria,	0	4	3
Ceratium,	0	0	1
Peridinium,	0	1	1
Trachelomonas,	0	0	1
Vorticella,	0	3	0
Vermes, Anurea,	0	0	1
Miscellaneous, Zoöglœa,	34	18	40
TOTAL,	71	204	52

Chemical Examination of Water from Millham Brook, Marlborou

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as	
								Albuminoid.					
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.
	1893.												
10192	Mar. 29	V. slight.	Slight.	0.45	3.45	0.95	.0010	.0146	.0118	.0028	.20	.0120	.0000
11536	Dec. 20	None.	V. slight.	0.60	6.15	2.25	.0006	.0178	.0154	.0024	.35	.0300	.0000

Iron, .0073. Odor, faintly vegetable.——The samples were collected from Millham Bro point from which water is drawn for the supply of Marlborough.

Microscopical Examination.

No. 10192. Miscellaneous, *Zoöglœa*, 36.

No. 11536. Diatomaceæ, *Meridion*, 2; *Synedra*, 5; Miscellaneous, *Zoöglœa*, 5. Total, 12.

MAYNARD.

WATER SUPPLY OF MAYNARD.

Chemical Examination of Water from the Maynard Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
10033	Feb. 17	V. slight.	Slight.	0.05	2.55	1.15	.0000	.0040	.0030	.0010	.29	.0000	.0000	.1297	0.9
10420	May 18	Slight.	Slight.	0.01	2.15	0.90	.0000	.0146	.0126	.0020	.23	.0000	.0000	.0949	0.2
10866	Aug. 21	Slight.	Slight.	0.00	2.30	1.00	.0000	.0104	.0068	.0036	.24	.0000	.0000	.1580	0.0
11368	Nov. 22	V. slight.	Slight.	0.00	1.70	0.50	.0004	.0182	.0096	.0036	.25	.0000	.0000	.1554	0.5
Av.	....	....	....	0.02	2.18	0.89	.0001	.0106	.0080	.0026	.25	.0000	.0000	.1345	0.4

Iron, .0038. Odor of the first sample, faintly earthy; of the second, distinctly vegetable and unpleasant; of the remaining samples, none. On heating, a faintly vegetable odor was noticeable in the second and third samples.——The first sample was collected from a faucet in the town, the remaining samples directly from the pond. The difference between the analysis of the sample collected in the village and those from the pond indicates that a large amount of ground water finds its way into the pipe leading from the pond to the pumping station.

Microscopical Examination of Water from the Maynard Water Works.

[Number of organisms per cubic centimeter.]

	1893. February.	1893. May.	1893. August.	1893. November.
Day of examination,	21	19	22	23
Number of sample,	10033	10420	10866	11368
PLANTS.				
Diatomaceæ,	**72**	**502**	**43**	**156**
Asterionella,	42	8	0	106
Cyclotella,	pr.	20	5	0
Diatoma,	1	0	4	0
Navicula,	1	0	2	pr.
Synedra,	18	34	9	42
Tabellaria,	10	440	23	8
Cyanophyceæ,	**0**	**4**	**44**	**7**
Clathrocystis,	0	4	0	0
Microcystis,	0	0	44	7
Algæ,	**0**	**3**	**4**	**10**
Conferva,	0	2	0	0
Protococcus,	0	0	0	7
Raphidium,	0	0	4	2
Scenedesmus,	0	1	0	1

MAYN

Microscopical Examination of Water from the Maynard Water Work
— Concluded.

[Number of organisms per cubic centimeter.]

	1893. February.	1893. May.	1893. August.	1893. Nove
ANIMALS.				
Rhizopoda, Actinophrys,	0	0	1	
Infusoria,	4	37	3	
Dinobryon,	0	3	0	
Dinobryon cases,	4	34	0	
Monas,	0	pr.	1	
Peridinium,	0	0	2	
Miscellaneous, Zoöglœa,	5	22	8	
TOTAL,	81	568	103	2

MEDFIELD.

Chemical Examination of Water from a Spring, Medfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	
10241	1893. April 12	None.	None.	0.0	3.00	.0004	.0002	.22	.0030	.0000	.0693	1.1	.

Odor, none, becoming very faintly vegetable on heating.——The sample was collected fro spring near Vine Brook about a third of a mile above North Street. This spring is used as a sou of water supply by a large straw factory, and by a portion of the village of Medfield.

Microscopical Examination.

Diatomaceæ, *Synedra*, 1.

WATER SUPPLY OF MEDFIELD INSANE ASYLUM.

Description of Works. — This asylum is a State institution whi had not been occupied up to the end of 1893. The water worl were completed in September, 1893. The supply is obtained fro a system of 20 two and one-half inch tubular wells, located c

two feet. These are approximately in two parallel lines and the extreme wells are about three hundred feet apart in an easterly and westerly direction, and one hundred and sixty feet in a northerly and southerly direction. As these wells did not furnish as much water as was desirable, in view of the low level of the water in Spot Pond, additional works were constructed early in 1894 for pumping water from the unpolluted upper portion of the brook.

Analyses of water from various sources within the town are given below. Further information regarding the water supply of Medford from Spot Pond may be found on pages 29–32 and 203, and analyses of water from the pond may be found on page 205.

Chemical Examination of Water from Tubular Wells used as an Additional Source of Water Supply for Medford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10690	July 19	None.	None.	0.0	12.30	.0004	.0002	.70	.0500	.0000	.0000	7.0	.0040
10744	Aug. 7	None.	None.	0.0	13.30	.0000	.0000	.64	.0700	.0000	.0000	8.3	.0040
11338	Nov. 15	None.	None.	0.0	13.80	.0000	.0000	.86	.0750	.0000	.0664	8.9	.0000
11476	Dec. 12	None.	None.	0.0	13.40	.0000	.0000	.85	.0650	.0000	.0336	8.9	.0000
Av...	....	....	....	0.0	13.20	.0001	.0001	.76	.0650	.0000	.0250	8.3	.0020

Odor, none.——The samples were collected from a faucet at the temporary pumping station while pumping.

Microscopical Examination.

An insignificant number of organisms were found in the first and third samples; in the others no organisms were found.

MEDFORD.

Chemical Examination of Water from Wells in Medford, collected during an Investigation for an Additional Water Supply.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9915	Jan. 23	None.	None.	0.00	11.20	.0000	.0000	.79	.0450	.0000	.0073	6.5	.0040
9946	Jan. 27	-	-	-	-	-	-	.68	.1250	-	-	-	-
9947	Jan. 27	-	-	-	-	-	-	.66	.0450	-	-	-	-
9948	Jan. 27	-	-	-	-	-	-	.66	.0450	-	-	-	-
9949	Jan. 27	-	-	-	-	-	-	.86	.1200	-	-	-	-
10256	April 17	V. slight, clayey.	V. slight.	0.05	14.60	.0000	.0002	.54	.0700	.0000	.0000	8.4	.0050
10257	April 17	Distinct, clayey.	Slight.	0.02	12.60	.0000	.0002	.71	.0600	.0010	.0000	6.3	.0220

Odor, none.——No. 9946 was collected from a tubular well at a house on Fulton Street near Valley Street; No. 9949 from a well at a house on Webster Street near Forest Street; the remaining samples from tubular test wells, at the location from which the additional supply of water is drawn.

Microscopical Examination.

No. 10257. Miscellaneous, *Zoöglœa*, 20. Nos. 9915 and 10256, no organisms. Nos. 9946, 9947, 9948 and 9949, not examined.

Chemical Examination of Water from a Brook near Forest Street, Medford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9914	Jan. 23	V. slight.	Cons.	0.20	5.30	0.75	.0044	.0132	.0118	.0014	.59	.0150	.0001	.4051	2.2

Iron, .0100. Odor, very faintly vegetable.——The sample was collected from the brook near the corner of Elm and Forest streets, Medford. Early in 1894 the town began pumping water from the brook at this point.

Microscopical Examination.

Diatomaceæ, *Meridion*, 1; *Navicula*, 1; *Nitzschia*, 1. Miscellaneous, *Zoöglœa*, 11. Total, 14.

Water Supply of Melrose.

Several communications of the State Board of Health to the town of Melrose, with reference to taking an additional water supply for the town from sources in North Andover, and from various sources within the town of Melrose, may be found on pages 34–40 of this volume.

MELROSE.

In August, 1893, an additional supply of water was introduced from a system of tubular wells, owned by a private company, and located in the westerly part of the town, near the boundary line between Melrose and Stoneham. The works consist of a system of fifteen two and one-half inch tubular wells varying in depth from thirty-five to forty-five feet, all located in the vicinity of Spot Pond Brook, north of Wyoming Avenue. The wells are connected with a temporary pump, and water is pumped directly into the main pipe in Wyoming Avenue, which conveys water from Spot Pond to the town.

Analyses of water from this source and from other sources within the town are given in the tables below. Further information regarding the water supply of Melrose from Spot Pond may be found on pages 29–32 and 203, and analyses of water from the pond on page 205.

Chemical Examination of Water from Tubular Wells in the Valley of Spot Pond Brook, near Wyoming Avenue, used as an Additional Source of Water Supply for Melrose.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10692	July 20	V. slight, clayey.	V. slight.	0.02	8.90	.0000	.0024	0.69	.0200	.0000	.0370	3.9	.0000
10867	Aug. 21	Distinct.	Slight.	0.02	9.20	.0004	.0000	0.71	.0000	.0003	.0474	4.4	.0070
10989	Sept. 6	None.	None.	0.00	9.00	.0000	.0008	0.81	.0000	.0001	.0312	4.3	.0312
11118	Sept. 29	None.	None.	0.00	10.40	.0000	.0018	1.17	.1500	.0000	.0385	6.0	.0080
11164	Oct. 11	None.	None.	0.00	11.40	.0000	.0018	1.25	.1100	.0001	.0077	6.3	.0040
11348	Nov. 16	Distinct, clayey.	Slight, clayey.	0.05	12.80	.0000	.0000	1.37	.0900	.0000	.0468	7.3	.0250
11497	Dec. 14	None.	None.	0.00	12.00	.0096	.0020	1.25	.0600	.0000	.0280	5.9	.0050
Av.	....	....	....	0.01	10.53	.0001	.0013	1.04	.0614	.0000	.0338	5.4	.0115

Odor, none. —— The first two samples were collected from the discharge pipe of the pump drawing water from the tubular wells; the remaining samples from a faucet at the temporary pumping station while pumping.

Microscopical Examination.

A few *Zoöglœa* were found in the samples collected in the latter part of September and in October and November. In the remaining samples no organisms were found.

ME

Chemical Examination of Water from Tubular Wells in the vicinity of S
Brook, North of Wyoming Avenue, near the Boundary between Mel
Stoneham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.	
	1892.										
10018	Feb. 13	Decided.	Cons., gray.	0.15	10.80	.0126	.0080	.70	.0400	.0014	.1147
10036	Feb. 20	Distinct, milky.	Cons.	0.10	8.90	.0090	.0026	.77	.0180	.0015	.0822

Note, — These wells were about 1,000 feet north-west of the wells from which the auxilia
of Melrose is drawn.

Odor of the first sample, distinctly earthy; of the last, none. —— The samples were colle
the wells while pumping.

Microscopical Examination.

No organisms.

Chemical Examination of Water from Ell Pond, Melrose.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		
								Albuminoid.						
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	
	1892.													
9897	Jan. 18	Distinct.	Cons.	0.30	10.15	2.60	.0388	.0194	.0166	.0028	1.47	.1200	.0011	.:

Iron, .0200. Odor, distinctly vegetable. —— The sample was collected from the pond near the
This pond is not used as a source of water supply.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 24; *Cyclotella*, 2; *Melosira*, 454; *Synedra*, 5. Cyanophyceæ, *Cla*
tis, 1. Algæ, *Chlorococcus*, 3; *Closterium*, 1; *Protococcus*, 37; *Raphidium*, 3; *Scenedes*
Infusoria, *Trachelomonas*, 14; *Vorticella*, 1. Miscellaneous, *Acarina*, .02; *Zoöglœa*, 100. Tota

METHUEN.

Chemical Examination of Water from a Brook and Tubular Test Wells in Sargent's Meadow, Methuen.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10277	Apr. 20	None.	V. slight.	0.12	3.50	.0006	.0056	.24	.0100	.0000	.1971	1.4	.0040
10276	Apr. 20	None.	None.	0.02	3.40	.0000	.0002	.31	.0050	.0000	.0146	1.1	.0070
10376	May 8	Slight, milky.	V. slight.	0.02	7.65	.0168	.0010	.25	.0070	.0003	.0730	3.0	.0210
Av...	....	....	....	0.05	4.85	.0058	.0023	.27	.0073	.0001	.0949	1.8	.0107

Odor of the first two samples, none; of the last, faint. —— The first sample was collected from a brook in Sargent's Meadow, in the easterly part of Methuen. This brook is a tributary of Bear Meadow Brook. The last two samples were from tubular wells in Sargent's Meadow; the first from a single well and the last from a group of seven two and one-half inch tubular wells, collected from the discharge pipe of a pump after pumping continuously for eight hours.

Microscopical Examination.

No. 10276. No organisms.
No. 10277. Diatomaceæ, *Meridion*, 16; *Synedra*, 4. Total, 20.
No. 10376. Diatomaceæ, *Asterionella*, 2.

Water Supply of Middleborough Fire District. — Middleborough.

Chemical Examination of Water from the Well of the Middleborough Fire District.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10242	Apr. 12	None.	None.	0.00	7.25	.0012	.0020	.78	.1200	.0001	.0511	2.6	.0010
11013	Sept. 12	V. slight.	V. slight.	0.10	5.80	.0000	.0028	.68	.0350	.0000	.1170	2.5	.0130

Odor, none. —— The samples were collected from a faucet at the pumping station while pumping.

Microscopical Examination.

No. 10242. Diatomaceæ, *Asterionella*, 3; *Synedra*, 9. Total, 12.

No. 11013. Diatomaceæ, *Pinnularia*, 1; Fungi, *Crenothrix*, 100; Infusoria, *Peridinium*, 1. Total, 102.

Water Supply of Middleton.

(See *Danvers*.)

MILTON.

Water Supply of Milton. — Milton Water Company.

The water supplied by this company to the town is purchased from the Hyde Park Water Company. A statement in regard to the supply and analyses of the water may be found on pages 173–176. Analyses of samples of water from Pine Tree Brook, and from a test well near it, made in connection with an investigation for a new source of water supply for Milton, are given below.

Chemical Examination of Water from Pine Tree Brook, Milton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
11429	1898. Nov. 30	None.	V. slight.	0.85	5.55	2.15	.0000	.0216	.0198	.0018	.75	.0030	.0000	.9438	1.1

Iron, .0100. Odor, faintly vegetable, becoming stronger on heating. —— The sample was collected from the brook at the site of a small dam on the westerly side of Harland Street, Milton.

Microscopical Examination.

Fungi, *Crenothrix*, 1. Miscellaneous, *Zoöglœa*, 3. Total, 4.

Chemical Examination of Water from a Tubular Test Well in the Valley of Pine Tree Brook, Milton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
11430	1898. Nov. 30	None.	Cons., sand.	0.0	4.70	.0000	.0000	.43	.1500	.0000	.0000	1.9	.0000

Odor, none. —— The sample was collected from a tubular well near Pine Tree Brook on the easterly side of Harland Street, and about 700 feet south of Canton Avenue, Milton.

Microscopical Examination.

No organisms.

MONTAGUE.

WATER SUPPLY OF TURNER'S FALLS FIRE DISTRICT. — MONTAGUE.

Chemical Examination of Water from Lake Pleasant, Montague.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9928	Jan. 23	V. slight.	V. slight.	0.03	3.30	1.20	.0090	.0482	.0326	.0156	.16	.0000	.0000	.2190	0.8
9972	Feb. 6	V. slight.	V. slight.	0.04	2.65	0.90	.0064	.0138	.0098	.0040	.15	.0050	.0001	.1153	0.9
10136	Mar. 16	Slight.	Slight, white.	0.08	1.20	0.55	.0012	.0060	.0032	.0028	.10	.0030	.0001	.0864	0.5
10168	Mar. 27	None.	Slight.	0.02	2.20	0.60	.0042	.0066	.0046	.0020	.10	.0150	.0001	.0985	0.6
10259	Apr. 17	V. slight.	V. slight.	0.04	2.25	0.30	.0014	.0082	.0048	.0034	.09	.0000	.0000	.0912	0.5
10392	May 15	V. slight.	V. slight.	0.03	2.25	0.25	.0000	.0072	.0054	.0018	.09	.0180	.0000	.1022	0.3
10516	June 13	V. slight.	None.	0.03	2.85	1.20	.0002	.0100	.0082	.0018	.14	.0030	.0000	.0703	0.3
10653	July 12	None.	V. slight.	0.02	1.60	0.35	.0000	.0054	.0040	.0014	.10	.0050	.0000	.0949	0.1
10812	Aug. 15	V. slight.	Slight.	0.01	1.90	0.60	.0000	.0064	.0054	.0010	.10	.0000	.0000	.0987	0.8
11022	Sept. 13	None.	V. slight.	0.03	2.50	0.85	.0000	.0074	.0052	.0022	.12	.0050	.0000	.0936	0.5
11162	Oct. 10	V. slight.	V. slight.	0.05	2.30	0.75	.0000	.0092	.0070	.0022	.12	.0000	.0000	.0885	0.5
11328	Nov. 13	None.	V. slight.	0.08	1.95	0.55	.0018	.0054	.0044	.0010	.11	.0040	.0000	.1867	0.5
11471	Dec. 11	None.	V. slight.	0.08	2.15	0.60	.0060	.0100	.0084	.0016	.11	.0050	.0000	.1120	0.6
Av.*	....	....	....	0.04	2.28	0.68	.0023	.0115	.0083	.0032	.12	.0045	.0000	.1137	0.6

Averages of Analyses of Previous Years.

-	1887†	-	-	0.03	2.74	0.81	.0018	.0116	-	-	.10	.0007	-	-	-
-	1888	-	-	0.00	2.33	0.49	.0027	.0071	-	-	.09	.0085	.0000	-	-
-	1889‡	-	-	0.01	2.19	0.40	.0008	.0063	.0052	.0011	.09	.0088	.0000	-	-
-	1893	-	-	0.04	2.28	0.68	.0023	.0115	.0083	.0032	.12	.0045	.0000	.1137	0.6

* Where more than one sample was collected in a month, the mean analysis for that month has been used in making the average. † June to December. ‡ January to June.

NOTE to analyses of 1893; Iron, .0065. Odor of the first sample, strongly vegetable and unpleasant, becoming strongly oily on heating; of the second sample, none, becoming decidedly oily on heating; of the last sample, decidedly vegetable and unpleasant; of the remaining samples, generally faintly vegetable or none. —— The first three samples were collected directly from the lake; the remaining samples from a faucet at the pumping station.

M

Microscopical Examination of Water from Lake Pleasant, Mont

[Number of organisms per cubic centimeter.]

	1893.										
	Jan.	Feb.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	O
Day of examination,	25	7	18	28	18	16	14	15	16	14	
Number of sample,	9928	9972	10136	10168	10259	10392	10516	10653	10812	11022	11
PLANTS.											
Diatomaceæ,	2	0	pr.	49	445	8	44	1	19	pr.	1
Cyclotella,	pr.	0	0	pr.	3	0	12	pr.	0	0	
Fragilaria,	0	0	0	0	5	0	14	1	14	0	
Melosira,	0	0	0	10	4	6	12	0	3	0	1
Synedra,	2	0	pr.	39	430	2	4	0	0	pr.	[illegible]
Tabellaria,	0	0	0	0	3	0	2	0	2	pr.	[illegible]
Algæ,	0	0	0	0	0	0	17	0	50	12	7
Chlorococcus,	0	0	0	0	0	0	0	0	0	2	7
Pandorina,	0	0	0	0	0	0	pr.	0	0	10	[illegible]
Protococcus,	0	0	0	0	0	0	17	0	50	0	[illegible]
ANIMALS.											
Infusoria,	9	510	pr.	3	2	0	0	0	1	pr.	0
Dinobryon,	0	196	0	0	2	0	0	0	0	0	0
Dinobryon cases,	9	314	0	3	0	0	0	0	1	0	0
Peridinium,	0	0	pr.	0	0	0	0	0	0	pr.	0
Vermes, Rotatorian ova,	0	0	0	0	0	0	0	0	2	0	0
Miscellaneous, Zoöglœa,	0	0	0	16	8	0	1	0	0	0	7
TOTAL,	11	510	pr.	68	455	8	62	1	72	12	99

WATER SUPPLY OF NAHANT.

(See *Swampscott.*)

WATER SUPPLY OF NANTUCKET. — WANNACOMET WATER CO

Wannacomet Pond, the source of supply of this compan
given trouble on several occasions owing to the presence
water of abundant growths of the organism *Anabæna*, whi
generally appeared about midsummer and disappeared in Oc
The pond is a natural basin with sandy shores and a muddy b
having an area of about eight acres and a general depth of
fourteen feet. It has no visible inlet or outlet and is supplied
water which percolates into it from the sandy territory with

The surface of the filter is level and about five feet above high-water mark in the pond, so that water has to be pumped upon it. The pond water is pumped through a six-inch pipe which rises vertically through the filtering material to the surface of the filter, and the water is kept at a depth of from twelve to eighteen inches above the surface of the sand. The filter was kept saturated and covered with water at all times, although, as it was the custom to pump water upon the filter and draw the filtered water from the collecting well at the same time, the filtration through the sand took place only while the pumps were in operation. As a rule air was forced through the aeration pipes during most of the time when the pumping was in progress.

The rate of consumption during the summer ranged from 150,000 to 220,000 gallons per day, so that the rate of filtration if it had been continued through the whole twenty-four hours would have been from 1,420,000 to 2,080,000 gallons per acre per day (1.4 to 2.0 gallons per square foot per hour). The pumps were generally operated from an hour to an hour and a half at a time, while the tank was being filled, and then shut down for three or four hours. Under these circumstances the filtration took place at a much more rapid rate than is above indicated. It is stated that the filter is intended to operate at the rate of five gallons per square foot per hour.

As already indicated, the *Anabœna* appeared in such numbers in 1893 as to cause complaint from the water consumers, and the operation of the filter was begun on August 8. At first the results appeared to be satisfactory, 98 per cent. of the organisms being removed from the water on August 14, and nearly all of the odor and color. After twelve days' use, while the filtered water still appeared to be clear, complaints of the odor of the water began to be made by the consumers. Two days later it was noticed that a scum had formed upon the surface of the sand and the filter had become clogged. This clogging was relieved by raking the surface, and did not occur again. After twenty-two days' use the odor of the filtered water was so strong that the use of the filter was discontinued, the water was drawn down and a layer half an inch in depth was removed from the surface of the filter. The greater part of the matter removed from the water by filtration was found within a

quarter of an inch of the surface. In some places, however, the sand was stained to a depth of eight or ten inches. It was also noticed that the air used in aerating the filter had passed up through the material unevenly and had come to the surface at several places where little craters were formed. The portion of the aerating pipes extending beneath the filter bed were accordingly disconnected and were not used again during the season. The filter was again used for a few days beginning September 1, but the odor of the filtered water was so strong that it was again discontinued. Up to this time light was admitted to the collecting well, but afterward it was excluded.

It is also to be noted that these unfavorable results were obtained during the portion of the year when the pond water had a high temperature, which was increased by the exposure of the water in a thin layer upon the filter bed and by the warm air pumped in for aeration from the engine-room. After September 29, when the temperature of the water was below sixty degrees Fahrenheit, the filter was operated without any trouble and there was said to be no odor. On October 18 the filtration was discontinued for the season, as the *Anabœna* had disappeared from the pond.

The results of the chemical and microscopical examinations as given in the following tables show that a very large proportion of the *Anabœna* were at all times removed by filtration, but at times there was a very abundant development of *Zoöglœa* in the filtered water. For instance, in the sample collected on September 20, when the unfiltered water contained 508 *Anabœna* and *Anabœna* spores per cubic centimeter, the number in the filtered water was 63. In the unfiltered water there were no *Zoöglœa* and in the filtered water 480. On this date the amount of organic matter as indicated by the albuminoid ammonia was reduced only about one-fourth, but as a rule nearly three-fifths of the organic matter was removed by filtration.

NA

Comparison of Examinations of Water from the Wannacomet Water Works before and after Filtration.

[NOTE. — Figures in bold-faced type show the results of examinations of water fı Figures in Roman type show results of examinations of the water after pa the filter.]

[Parts per 100,000.]

Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Odor. Cold.	Odor. Hot.	Ammonia. Free.	Ammonia. Albuminoid.	Oxygen Consumed.	
1898.								
Aug. 14	**De'ded, green.**	**Cons., rusty.**	**Distinctly disagreeabe.**	**Dist'ly v'g'ble and grassy.**	**.0110**	**.0526**	**.260**	
Aug. 14	None.	None.	Faintly disagreeable.	Faintly vegetable.	.0000	.0168	.146	
Aug. 22	**De'ded, green.**	**Slight, yellow.**	**Dist'ly v'g'ble & disag'ble.**	**Dist'ly v'g'ble and grassy.**	**.0002**	**.0590**	**.264**	
Aug. 22	Distinct.	Slight.	Faintly vegetable.	Faintly vegetable.	.0122	.0108	.135	
Aug. 29	**Dist'ct, green.**	**Cons., brown.**	**De'd'ly v'g'ble & disag'ble.**	**Stro'gly vegetable, grassy.**	**.0000**	**.0638**	**.3397**	
Aug. 29	V. slight, milky.	V. slight.	Decidedly vegetable & unpleasant.	De'd'ly vegetable and disagreeable.	.0206	.0212	.1659	
Sept. 6	**De'ded, green.**	**Slight, yellow.**	**Dist'ly v'g'ble & disag'ble.**	**De'd'd, sw'ish and grassy.**	**.0000**	**.0258**	**.2925**	
Sept. 6	Distinct, yellow.	Slight.	Decided, disagreeable.	Decided, disagreeable.	.0096	.0226	.1560	
Sept. 13	**De'ded, green.**	**Slight, yellow.**	**Distinctly vegetable.**	**Distinctly vegetable.**	**.0000**	**.0698**	**.2184**	
Sept. 13	Slight, milky.	Slight.	Decided, vegetable.	Decided, disagreeable.	.0000	.0224	.1950	
Sept. 20	**De'ded, green.**	**Slight, yellow.**	**De'd'ly v'g'ble and grassy.**	**De'ded, sweet, grassy.**	**.0000**	**.0670**	**.2706**	
Sept. 20	Decided, green.	Slight.	Decided, disagreeable.	Decided, disagreeable.	.0098	.0516	.3649	
Oct. 4	**Dist'ct, green.**	**Cons., green.**	**Distinctly unpleasant.**	**De'd'ly v'g'ble and grassy.**	**.0000**	**.0574**	**.1463**	
Oct. 4	Slight, milky.	V. slight.	Decidedly unpleasant.	Decidedly grassy and unpleasant.	.0014	.0176	.1155	
Oct. 11	**Dist'ct, green.**	**Cons.**	**De'd'ly v'g'ble & disag'ble.**	**De'd'ly v'g'ble and grassy.**	**.0010**	**.0442**	**.1863**	**1,**
Oct. 11	Slight, milky.	V. slight.	Dist'ly vegetable and disagreeable.	Dist'ly vegetable and grassy.	.0004	.0112	.1174	
Oct. 18	**Dist'ct, milky.**	**Slight.**	**Faint'y v'g'ble and grassy.**	**Str'gly v'g'ble and grassy.**	**.0022**	**.0286**	**.1368**	
Oct. 18	None.	None.	Distinctly vegetable.	Very faintly vegetable.	.0000	.0056	.0912	
Av.					**.0016**	**.0520**	**.2351**	**1,0**
Av.					.0060	.0200	.1653	

NANTUCKET.

Microscopical Examination of Water from Wannacomet Pond, Nantucket.

[Number of organisms per cubic centimeter.]

	1893.												
	Aug.	Aug.	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct	Nov.	Dec.
Day of examination, . .	16	24	31	9	15	22	30	6	12	21	27	11	8
Number of sample, . .	10801	10874	10922	10982	11025	11070	11117	11146	11176	11228	11253	11315	11465
PLANTS.													
Diatomaceæ, Synedra,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**pr.**	**400**
Cyanophyceæ, . .	**2,224**	**1,100**	**467**	**336**	**925**	**508**	**176**	**968**	**1,748**	**800**	**449**	**5**	**0**
Anabæna, . . .	2,160	760	200	228	860	356	176	968	1,748	744	440	5	0
Anabæna spores, . .	64	340	260	108	65	152	0	0	0	56	9	0	0
Microcystis, . . .	0	0	7	0	0	0	0	0	0	0	0	0	0
Algæ, ...	**16**	**2**	**9**	**1**	**25**	**10**	**0**	**0**	**0**	**1**	**9**	**36**	**14**
Pandorina, . . .	10	0	1	1	0	0	0	0	0	0	7	0	0
Protococcus, . .	0	0	3	0	25	10	0	0	0	0	0	1	12
Scenedesmus, . .	4	2	2	0	0	0	0	0	0	0	2	34	2
Staurastrum, . .	2	0	3	0	0	0	0	0	0	1	0	1	0
Fungi, Crenothrix, .	**56**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**0**	**1**	**0**
ANIMALS.													
Infusoria, . . .	**8**	**9**	**20**	**2**	**0**	**0**	**0**	**2**	**10**	**3**	**21**	**354**	**16**
Cryptomonas, . .	0	0	0	0	0	0	0	0	0	0	0	0	7
Dinobryon, . . .	0	0	0	0	0	0	0	0	0	0	10	60	0
Dinobryon cases, .	0	0	0	0	0	0	0	0	0	0	0	260	4
Euglena, . . .	2	0	0	0	0	0	0	0	0	0	0	pr.	0
Glenodinium, . .	0	0	0	0	0	0	0	0	0	0	0	0	2
Monas, ...	4	0	0	0	0	0	0	0	8	0	0	0	0
Peridinium, . . .	2	9	20	2	0	0	0	2	2	3	6	34	3
Vorticella, . . .	0	0	0	0	0	0	0	0	0	0	5	0	0
Vermes, ...	**6**	**4**	**9**	**4**	**0**	**0**	**0**	**4**	**0**	**7**	**16**	**6**	**3**
Anuræa, . . .	4	1	5	3	0	0	0	2	0	6	15	5	0
Monocerca, . . .	0	0	0	0	0	0	0	2	0	0	0	0	0
Polyarthra, . . .	2	2	0	1	0	0	0	0	0	0	0	1	3
Rotatorian ova, . .	2	0	1	0	0	0	0	0	0	1	1	0	0
Rotifer, ...	0	1	3	0	0	0	0	0	0	0	0	0	0
Crustacea, . . .	**.08**	**0**	**.02**	**.01**	**.10**	**.07**	**0**	**0**	**0**	**0**	**0**	**.01**	**.04**
Cyclops, . . .	0	0	0	0	0	.02	0	0	0	0	0	.01	.04
Daphnia, . . .	.08	0	.02	.01	.10	.05	0	0	0	0	0	0	0
Miscellaneous, . . .	**144**	**76**	**200**	**0**	**.10**	**0**	**208**	**136**	**72**	**6**	**0**	**2**	**5**
Acarina, . . .	0	.01	0	0	.10	0	0	.04	.04	0	0	0	0
Zoöglœa, . . .	144	76	200	0	0	0	208	136	72	6	0	2	5
TOTAL, ...	2,456	1,191	705	343	950	518	386	1,112	1,830	817	497	404	438

CK.

Hardness.

5

NATICK.

Microscopical Examination of Water from Dug Pond, Natick.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	5	7	3	4	3	2	7	4	2	3	3	6
Number of sample,	9845	9975	10075	10206	10348	10471	10598	10725	10945	11130	11281	11442
PLANTS.												
Diatomaceæ,	494	3	9	30	778	13	105	145	39	10	432	1,465
Asterionella,	68	0	0	pr.	58	0	0	0	0	5	36	720
Cyclotella,	338	3	0	1	78	7	68	144	1	0	24	80
Melosira,	48	0	9	26	600	5	29	0	36	0	360	640
Synedra,	40	0	pr.	3	42	0	0	1	2	1	0	2
Tabellaria,	0	0	0	0	0	1	8	0	0	4	12	23
Cyanophyceæ,	pr.	0	0	0	0	0	0	3	11	0	2	0
Clathrocystis,	pr.	0	0	0	0	0	0	3	4	0	0	0
Microcystis,	0	0	0	0	0	0	0	0	7	0	2	0
Algæ,	24	0	pr.	pr.	50	10	137	12	21	14	133	24
Chlorococcus,	2	0	0	0	0	0	0	1	0	14	12	0
Closterium,	3	0	pr.	pr.	0	0	1	1	1	0	14	24
Glœocystis,	0	0	0	0	0	0	36	0	2	0	7	0
Protococcus,	14	0	0	0	4	10	100	10	16	0	100	0
Raphidium,	5	0	0	0	0	0	0	0	2	0	0	0
Zoöspores,	0	0	0	0	46	0	0	0	0	0	0	0
Fungi, Crenothrix,	1	0	pr.	2	0	0	0	0	0	3	pr.	0
ANIMALS.												
Rhizopoda, Difflugia,	1	0	pr.	0	0	pr.	0	0	0	0	0	0
Infusoria,	pr.	pr.	0	pr.	4	pr.	53	0	3	0	15	4
Dinobryon cases,	pr.	0	0	0	1	0	52	0	0	0	14	3
Monas,	0	0	0	0	0	0	1	0	1	0	pr.	0
Peridinium,	0	pr.	0	pr.	2	0	pr.	0	2	0	0	1
Trachelomonas,	pr.	pr.	0	0	pr.	pr.	pr.	0	0	0	1	0
Vorticella,	pr.	0	0	0	1	0	0	0	0	0	0	0
Vermes, Anurea,	pr.	pr.	0	0	0	0	0	1	5	0	0	0
Miscellaneous,	18	0	12	0	2	0	3	28	10	98	9	2
Acarina,	0	0	0	0	.01	0	0	0	0	.32	.01	0
Zoöglœa,	18	0	12	0	2	0	3	28	10	98	9	2
TOTAL,	538	3	21	32	834	23	298	189	89	125	591	1,495

NATICK.

Table showing Heights of Water in Dug Pond on Dates when Samples of Water were collected for Analysis.

NOTE. — High-water mark is 13.0 feet.

DATE. — 1893.	Height of Water.	DATE. — 1893.	Height of Water.
	Feet.		Feet.
Jan. 3,	8.75	July 5,	11.58
Feb. 6,	8.38	Aug. 3,	10.25
Mar. 2,	10.88	Sept. 1,	9.75
April 3,	13.29	Oct. 2,	8.92
May 5,	14.00	Nov. 1,	8.50
June 1,	13.00	Dec. 4,	8.83

WATER SUPPLY OF NEEDHAM.

Chemical Examination of Water from the Well of the Needham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			Residue on Evaporation.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10035	Feb. 20	None.	None.	0.0	4.80	.0000	.0012	.68	.1300	.0000	.0277	2.5	.0000
10435	May 23	None.	None.	0.0	5.90	.0000	.0002	.73	.2000	.0000	.0450	1.9	.0000
10865	Aug. 21	None.	None.	0.0	5.60	.0000	.0000	.56	.0750	.0000	.0735	1.6	.0000
11329	Nov. 14	None.	None.	0.0	5.10	.0000	.0018	.58	.1000	.0000	.0664	1.8	.0000
11503	Dec. 18	None.	None.	0.0	5.00	.0000	.0004	.59	.1100	.0000	.0486	1.6	.0000
Av.				0.0	5.28	.0000	.0007	.63	.1230	.0000	.0522	1.9	.0000

Odor, none.——Nos. 10435 and 11508 were collected from faucets in the village; the remaining samples either directly from the well or from a faucet at the pumping station while pumping.

Microscopical Examination.

An insignificant number of organisms was found in all but one of these samples.

NEW BEDFORD.

WATER SUPPLY OF NEW BEDFORD.

Chemical Examination of Water from the Conduit of the New Bedford Water Works.

[Parts per 100,000.]

Number.	Date of Collection.				Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9950	Jan. 30			0	6.80	3.00	.0056	.0286	.0236	.0050	.62	[illegible]	.0001	1.4965	1.8
10063	Mar. 1			5	4.80	2.30	.0008	.0184	.0160	.0024	.48	.0070	.0001	1.1268	1.7
10185	Mar 29			0	4.25	2.[illegible]	.0004	.0146	.0130	.0016	.38	.0150	.0001	0.8468	0.8
10438	May 23			0	4.65	2.15	.0012	.0236	.0224	.0012	.37	[illegible]	[illegible]	1.3237	0.3
10563	June 26			0	4.56	2.00	.0012	.0232	.0200	.0032	.48	.0070	.0001	1.2442	0.6
10696	July 25			0	4.65	2.60	.0020	.0268	.0226	.0042	[illegible]	.0030	.0002	1.0700	0.9
10896	Aug. 28			0	3.95	1.70	.0004	.0170	–	–	.49	.0000	.0002	1.0428	0.3
11115	Sept. 28			5	4.15	1.90	.0000	.0254	.0180	.0074	.50	.0030	.0000	0.6776	1.3
11235	Oct. 23			5	6.65	3.35	.0000	[illegible]	.0184	.0036	.54	[illegible]	[illegible]	0.5548	0.6
11393	Nov. 27	V. slight.	V. slight.	0.90	4.95	1.85	.0088	.0216	.0166	.0050	.61	.0030	.0002	1.0277	1.6
11505	Dec. 17	V slight	Slight.	1.00	6.00	2.80	.0040	.0196	.0180	.0016	.67	.0050	.0001	1.0732	1.4
Av.	....	....	....	1.35	5.05	2.36	.0022	*.0224	.0189	.0035	.51	.0061	.0001	1.0440	1.0

Averages of Analyses of Previous Years.

–	1887†	–	–	1.37	5.16	1.95	.0021	.0296	–	–	.56	.0137	–	–	–
–	1888	–	–	1.48	5.19	2.32	.0014	.0254	–	–	.53	.0163	.0001	–	–
–	1889	–	–	1.51	3.96	1.74	.0014	.0241	.0206	.0035	.50	.0103	.0001	–	–
–	1890	–	–	1.48	5.01	2.41	.0013	.0232	.0106	[illegible]	.45	.0125	.0001	–	1.2
–	1891	–	–	0.95	3.90	1.81	.0005	.0197	.0171	.0026	.42	.0103	.0000	–	0.8
–	1892	–	–	1.10	4.87	2.24	.0006	.0227	.0194	.0033	.52	[illegible]	.0001	–	1.0
–	1893	–	–	1.35	5.06	2.36	.0022	.0224	.0189	.0035	.51	.0051	.0002	1.0440	1.0

* Exclusive of No. 10896. † June to December.

NOTE to Analyses of 1893; Iron, .0223. Odor, vegetable and grassy or sweetish. —— The samples were collected from the conduit at its entrance to the receiving reservoir. Water from Little Quittacas Pond was drawn into the storage reservoir from July 23 to about Oct. 1, 1893.

Microscopical Examination of Water from the Conduit of the New Water Works.

[Number of organisms per cubic centimeter.]

	[illegible]								
	Jan.	Mar.	Mar.	May.	June.	July.	Aug.	Sept.	Oct
Day of examination,	31	2	30	24	27	26	29	30	2
Number of sample,	9950	10063	10185	10438	10563	10696	10896	11115	1128
PLANTS.									
Diatomaceæ,	0	0	3	28	1	1	1	0	1
Asterionella,	0	0	1	8	0	0	0	0	0
Synedra,	0	0	2	20	1	1	1	0	1
Cyanophyceæ,	0	0	0	0	0	110	16	0	0
Clathrocystis,	0	0	0	0	0	6	0	0	0
Merismopedia,	0	0	0	0	0	104	16	0	0
Algæ, Protococcus,	0	pr.	0	0	[illegible]	58	12	0	0
Fungi, Crenothrix,	pr.	pr.	1	16	3	2	26	0	3
ANIMALS.									
Infusoria,	5	pr.	10	1	0	0	2	0	0
Dinobryon,	5	0	3	0	0	0	0	0	0
Dinobryon cases,	pr.	pr.	pr.	1	0	0	0	0	0
Peridinium,	pr.	pr.	7	0	0	0	1	0	0
Trachelomonas,	0	0	0	0	0	0	1	0	0
Miscellaneous, Zoöglœa,	126	44	10	28	24	36	94	26	8
TOTAL,	131	44	24	73	28	207	151	26	12

Chemical Examination of Water from Little Quittacas Pond, Lakev

[Parts per 100,000.]

* Where more than one sample was collected in a month the mean analysis for that month used in making the average.

Iron, .0032. Odor of No. 10706, distinctly vegetable; of No. 11506, faintly vegetable; of t ing samples, none.—The samples were collected from the pond generally about five fe the surface.

Water Supply of Newburyport.—Newburyport Water Company.

The use of water from the Merrimack River by the Newburyport Water Company for the supply of the city was the subject of a communication from the State Board of Health* to the company in November, 1892, pointing out the danger of infection from typhoid fever incurred by the use of this source and advising that a further supply of pure water be obtained without delay. The continued use of the river water was the apparent cause of an epidemic of typhoid fever in Newburyport in January and February, 1893, which led the Board to send a letter relative to this subject to the mayor of the city early in March, a copy of which may be found on page 43 of this volume. The city of Newburyport subsequently applied to the State Board of Health for advice relative to the use of water from the Artichoke River, either directly or after filtration, for the supply of the city, and the reply of the Board may be found on page 44.

The Newburyport Water Company increased its ground-water supply in 1893 by taking the Jackman Spring, so called, and providing a temporary pump and pipe to pump and convey the water from this spring to the present works. It also constructed a well about fifty feet in diameter and fourteen or more feet in depth, a short distance from its present wells, and near the edge of the small reservoir by the pumping station. The works as enlarged, however, are not likely to furnish a sufficient supply for the city of Newburyport.

It will be noticed by reference to the table of analyses on page 242 that a very unusual amount of chlorine was at times present in the water supplied by the company to the city. This result is due to the use of water from the Merrimack River which contained a small amount of sea water.

Analyses of water from the Artichoke River, and from other sources, examined in connection with the investigation of new sources of water supply by the city, will be found in tables which follow.

* Report of the State Board of Health for the year 1892, page 37.

Chemical Examination of Water from the Small Storage Reservoir of the Newburyport Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
11387	Nov. 25	Distinct, clayey.	Slight, clayey.	0.10	6.00	0.70	.0000	[illegible]	.0020	.0016	.44	[illegible]	.0006	.1728	2.7

Iron, .0350. Odor, distinctly vegetable. —— The sample was collected from the reservoir near the pumping station.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 1; *Meridion*, 1; *Synedra*, 13. Algæ, *Conferva*, 2. Fungi, *Crenothrix*, 4. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 4. Total, 26.

Chemical Examination of Water from a Faucet in Newburyport, supplied from the Works of the Newburyport Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9881	Jan. 16	None.	None.	0.02	10.00	.0016	.0096	2.88	.0300	.0000	.2176	3.0	.0200
9905	Jan. 19	None.	V. slight.	0.10	6.10	.0012	.0030	.91	.0300	.0000	.1826	2.2	.0125
9940	Jan. 23	-	-	-	-	-	-	21.40	-	-	-	-	-
9970	Feb. 6	Slight, clayey.	V. slight.	0.08	31.95	.0062	.0102	14.54	.0090	.0003	.2445	7.3	.0180
10086	Mar. 7	V. slight.	V. slight.	0.08	5.55	.0012	.0012	.60	.0150	.0001	.1584	2.2	.0170
10212	Apr. 5	Distinct, clayey.	Slight.	0.20	5.50	.0018	.0058	.38	.0350	.0001	.1241	1.9	.0125
10364	May 8	Decided, clayey.	Slight, earthy.	0.30	6.30	.0022	.0072	.41	.0160	.0000	.1064	1.9	.0150
10490	June 7	V. slight, clayey.	Slight.	0.10	5.30	.0004	.0052	.46	.0150	.0000	.1606	2.2	.0120
10609	July 6	V. slight	Slight.	0.05	6.00	.0004	.0040	.40	.0180	.0000	.0730	2.1	.0120
10756	Aug. 9	Distinct, clayey.	V. slight.	0.20	6.50	.0000	.0040	.46	.0070	.0000	.1343	2.2	.0200
11011	Sept. 11	Slight.	Slight.	0.10	7.30	.0000	.0038	1.29	.0070	.0000	.0936	2.7	.0200
11159	Oct. 9	V. slight.	None.	0.05	5.50	.0000	.0010	.46	.0150	.0000	.0192	2.2	.0200
11306	Nov. 8	Distinct.	None.	0.08	6.00	.0000	.0024	.47	.0180	.0000	.0680	2.3	.0160
Av. . .	1893	. . . .	. . . .	0.11	8.50	.0013	.0048	3.44	.0178	.0000	.1391	2.7	.0164
Av. . .	1887-88*	. . . .	. . . .	0.03	5.39	.0004	.0082	0.45	.0312	.0001	-	-	-

* June, 1887, to May, 1888.

Odor, vegetable, frequently none. —— The samples were collected from a faucet at No. 2 State Street.

Microscopical Examination of Water from a Faucet in Newburyport, supplied from the Works of the Newburyport Water Company.

[Number of organisms per cubic centimeter.]

	1893.												
	Jan.	Jan.	Jan.	Feb.	Mar.	Apr.	May	June.	July.	Aug.	Sept.	Oct.	Nov.
Day of examination,	17	21	–	7	8	7	9	9	7	10	13	10	10
Number of sample,	9881	9905	9940	9970	10066	10212	10364	10490	10609	10756	[illegible]	11159	11386
PLANTS.													
Diatomaceæ,	34	0	–	4	1	1	490	3	pr.	300	6	5	0
Diatoma,	1	0	–	0	0	0	0	0	0	300	0	0	0
Fragilaria,	0	0	–	0	0	0	7	2	0	0	0	5	0
Synedra,	7	0	–	4	1	1	480	1	pr.	0	2	0	0
Tabellaria,	26	0	–	0	0	0	3	0	0	0	4	0	0
Fungi, Crenothrix,	0	0	–	0	1	0	0	0	0	0	36	0	0
ANIMALS.													
Infusoria,	2	0	–	pr.	0	0	78	60	2	1	169	pr.	0
Dinobryon,	0	0	–	0	0	0	8	0	0	0	0	0	0
Dinobryon cases,	2	0	–	pr.	0	0	68	60	2	0	168	0	0
Monas,	0	0	–	0	0	0	2	0	0	0	0	0	0
Peridinium,	0	0	–	pr.	0	0	0	0	0	1	1	pr.	0
Miscellaneous, Zoöglœa,	84	0	–	8	232	0	6	16	0	0	92	10	76
TOTAL,	120	0	–	12	234	1	574	79	2	301	303	15	76

Chemical Examination of Water from Tubular Test Wells at Newburyport.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.						Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.							
	1893.													
11388	Nov. 25	Slight, clayey.	Cons., sand.	0.0	19.80	.0006	.0006	2.68	.0300	.0003		.1032	11.8	.0020
11390	Nov. 25	None.	None	0.0	19.80	.0010	.0002	2.12	.0000	.0000		.0731	10.7	.0100
11423	Nov. 29	Distinct, clayey.	Cons., clayey.	0.0	24.70	.0012	.0004	1.50	.0000	.0000		.1435	9.0	1140
Av.	....	....	....	0.0	21.43	.0009	.0004	2.10	[illegible]	.0001		.3250	1.05	.0420

Odor, none. —— The first sample was collected from a tubular test well just below Frost's ice pond in the valley of a tributary of Little River, about one mile south-west of the centre of the city of Newburyport; the second sample from a tubular test well located on the northerly side of Little River just below the point where it is crossed by the Byfield road, about on the line between Newburyport and Newbury; the last sample, from a tubular test well in the valley of Little River, about half a mile or more north-west of the well last described.

Microscopical Examination.

No. 11388. No organisms.
No. 11390. Miscellaneous, *Zoöglœa*, 1.
No. 11423. Diatomaceæ, *Synedra*, 1. Miscellaneous, *Zoöglœa*, 1. Total, 2.

Chemical Examination of Water from the Artichoke River in West Newbury.

[Parts per 100,000.]

Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
).55	6.60	2.25	.0000	.0254	.0214	.0040	.59	.0050	.[illegible]	.6206	2.1
).65	6.60	1.00	.0000	0182	.0162	.0020	.68	.0050	.0002	.5109	2.6
).70	7.70	2.55	.0008	.0240	.0222	.0018	.82	.0000	.0165	.9116	3.5
).50	6.60	1.20	.0000	.0162	.0144	.0018	.67	.0030	.0001	.4719	2.6
).58	6.60	1.75	0002	.0210	.0186	.0024	.69	.0028	.0042	.6287	2.7

Iron, of the first sample, .0055; of the second, .0120; of the last two, .0110. Odor of the first two samples, faintly vegetable; of the last two, distinctly vegetable. —— The first two samples were collected from the Artichoke River, about two miles above its mouth, at the Quaker Church Road crossing; the last two samples from the west branch of the Artichoke River at the first road crossing above its junction with the main stream.

Microscopical Examination.

The total number of organisms found in each of these samples was as follows: —
No. 10265, 42; No. 11467, 3; No. 11389, 12; No. 11465, 8.

Water Supply of Newton.

Chemical Examination of Water from a Faucet at the Newton Water Works Pumping Station.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9912	Jan. 23	None.	None.	0.00	5.05	.0000	.0012	.41	.0250	.0000	.0401	2.2	.0050
10149	Mar. 22	Slight.	Cons.	0.10	4.65	.0010	.0034	.40	.0120	.0000	.1548	2.2	.0260
10406	May 17	Slight	V. slight.	0.03	5.45	.0000	.0020	.40	.0350	.0000	.0474	2.2	.0110
10630	July 10	V. slight.	V. slight.	0.00	5.20	.0008	.0022	.31	.0250	.0000	.0611	2.1	.0050
11354	Nov. 21	None.	Slight.	0.02	5.05	.0000	.0008	.36	.0000	.0000	.1344	2.6	.0125
Av....	....	....	....	0.03	5.08	.0004	.0019	.38	.0194	.0000	.0856	2.3	.0119

Averages of Analyses of Previous Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.
-	1887*	-	-	0.00	4.97	.0005	.0070	.38	.0047	-	-	-	-
-	1888	-	-	0.01	4.64	.0009	.0111	.35	.0072	.0001	-	-	-
-	1889	-	-	0.00	3.93	.0002	.0061	.30	.0126	.0001	-	-	-
-	1890†	-	-	0.00	-	.0000	.0014	.32	.0250	.0001	-	-	-
-	1891†	-	-	0 00	4.25	.0002	.0072	.31	.0250	.0000	-	1.8	-
-	1892	-	-	0 02	5.13	0006	.0028	.35	.0190	.0001	-	2.4	-
-	1893	-	-	0 03	5.08	.0004	.0019	.38	.0194	.0000	.0856	2.3	.0119

* June to December. † February.

Note to analyses of 1893; Odor of 10149, very faintly vegetable; of the remaining samples, none. —— The samples were collected from a faucet at the pumping station, and represent the water as it comes from the covered filter gallery.

Analyses for the years 1887 to 1890, inclusive, represent water drawn from an open filter-basin. In 1890 the works for collecting ground water were enlarged by the construction of a long wooden filter-gallery, reinforced by tubular wells. A portion of this gallery, seven hundred and thirty-two feet in length, replaced an equal portion of the old open filter basin. In 1892 the remaining portion of the open filter-basin was replaced by an extension of the filter gallery, and after December of that year the water pumped for the supply of the city was not exposed to light at any point.

Microscopical Examination of Water from a Faucet at the Newton V Pumping Station.

[Number of organisms per cubic centimeter.]

	1893.			
	January.	March.	May.	July.
Day of examination,	24	23	18	13
Number of sample,	9912	10149	10406	10680
PLANTS.				
Diatomaceæ,	0	0	7	18
Cyclotella,	0	0	pr.	12
Fragilaria,	0	0	0	3
Melosira,	0	0	6	0
Synedra,	0	0	1	3
Algæ,	0	pr.	5	6
Closterium,	0	0	0	3
Protococcus,	0	0	0	3
Zoöspores,	0	pr.	5	0
Fungi, Crenothrix,	0	0	1	26
ANIMALS.				
Infusoria, Trachelomonas,	0	pr.	pr.	0
Miscellaneous, Zoöglœa,	32	7	86	18
TOTAL,	32	7	99	68

Chemical Examination of Water from the Covered Distributing Reserv Newton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
	1893.										
9911	Jan. 23	None.	V. slight.	0.00	5.55	.0000	.0016	.40	.0200	.0000	.0438
10148	Mar. 22	Slight.	Cons., earthy.	0.10	6.35	.0000	.0040	.42	.0150	.0001	.0504
10405	May 17	None.	Slight.	0.02	6.95	.0000	.0030	.39	.0400	.0000	.0511
10689	July 10	V. slight.	Slight, rusty.	0.02	7.00	.0000	.0024	.32	.0200	.0000	.0511
11355	Nov. 21	V. slight.	V. slight.	0.06	6.15	.0000	.0026	.38	.0150	.0000	.1428
Av...	....	....	....	0.04	6.40	.0000	.0027	.38	.0220	.0000	.0678

Odor of No. 10148, very faintly vegetable; of No. 10405, faintly unpleasant; of the samples, none. The odor of No. 11355 became distinctly unpleasant after standing in the one day.——The samples were collected from the reservoir.

NEW

Microscopical Examination of Water from the Main Underdrain of the B Brook Division of the Newton Sewerage System.

[Number of organisms per cubic centimeter.]

	1893. Jan.	July.	July.	Aug.	Aug.	Oct.
Day of examination,	14	7	31	8	29	25
Number of sample,	9873	10603	10714	10737	10894	11246
PLANTS.						
Diatomaceæ,	0	pr.	0	25	0	0
Melosira,	0	0	0	5	0	0
Synedra,	0	pr.	0	20	0	0
Algæ, Pediastrum,	0	0	0	15	0	0
Fungi,	0	12	6	13	0	8
Crenothrix,	0	0	0	7	0	3
Molds,	0	12	6	6	0	5
ANIMALS.						
Infusoria, Monas,	pr.	14	0	0	0	0
Miscellaneous, Zoöglœa,	0	pr.	6	14	2	88
TOTAL,	pr.	26	12	67	2	96

Chemical Examination of Water from Main Underdrain of the Cheeseca Brook Division of the Newton Sewerage System.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Sediment.	Color.	Residue on Evaporation.	Ammonia. Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
	1893.											
10713	July 31	Distinct.	Cons.	0.03	13.10	.0076	.0018	1.40	.4000	.0004	.0000	4.8
10736	Aug. 7	Decided.	Cons., rusty.	0.05	14.20	.0038	.0008	1.56	.3000	.0004	.0000	5.6
10895	Aug. 28	Distinct.	Heavy.	0.10	14.40	.0072	.0014	1.50	.2500	.0002	.0592	5.6
11245	Oct. 24	Distinct, milky.	Cons., fibrous.	0.18	20.40	.0050	.0012	1.53	.2900	.0010	.0494	6.0
11564	Dec. 30	Distinct.	Heavy.	0.01	15.50	.0120	.0022	1.59	.3250	.0008	.0077	7.4
Av.*	....	....	....	0.08	15.83	.0075	.0016	1.51	.3225	.0006	.0217	6.0

* Where more than one sample was collected in a month the mean analysis for that month has b used in making the average.

Odor of the first sample, faintly mouldy; of the second, none, becoming faintly earthy on heat of the last sample, none, becoming faintly vegetable on heating; of the remaining samples, none. The samples were collected from the underdrain at its outlet.

NEWTON.

Microscopical Examination of Water from the Main Underdrain of the Cheesecake Brook Division of the Newton Sewerage System.

[Number of organisms per cubic centimeter.]

	[illegible]				
	July.	August.	August.	October.	January.
Day of examination,	31	8	29	25	1
Number of sample,	10713	10736	10895	11245	11604
PLANTS.					
Fungi, Crenothrix,	1,000	[illegible]	[illegible]	1,920	[illegible]
ANIMALS.					
Infusoria, Monas,	0	1	0	0	[illegible]
Miscellaneous, Zoöglœa,	160	[illegible]	32	15	2
TOTAL,	1,160	3,921	872	1,935	[illegible]

Chemical Examination of Water from the Main Underdrain beneath the Laundry Brook Valley Sewer, Newton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	[illegible].												
11247	Oct. 24	Slight,	Cons.,	0.15	17.90	.0002	.0024	1.87	[illegible]	.0010	.0968	6.6	[illegible]

Water Supply of Northampton.

Chemical Examination of Water from the Upper and Lower Storage Reservoirs of the Northampton Water Works on Roberts' Meadow Brook.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10836	Aug. 16	None.	V. slight.	0.05	5.40	1.50	.0000	.0038	.0028	.0010	.11	.0070	.0000	.1404	1.9
10837	Aug. 16	Distinct.	Slight.	0.12	5.55	1.70	.0000	.0140	.0076	.0064	.12	.0000	.0000	.2028	1.9

Iron in the first sample, .0040; in the last, .0165. Odor of the first sample, none, becoming distinctly vegetable on heating; of the last sample, none.——The first sample was collected from the upper reservoir at Roberts' Meadow; the last from the lower reservoir at Leeds.

Microscopical Examination.

No. 10836. Diatomaceæ, *Fragilaria*, 5; *Gomphonema*, 4; *Synedra*, 1. Miscellaneous, *Zoöglœa*, 28. Total, 38.

No. 10837. Diatomaceæ, *Cyclotella*, 2; *Diatoma*, 2; *Epithemia*, 2; *Fragilaria*, 14; *Gomphonema*, 2; *Melosira*, 4; *Navicula*, 1; *Pinnularia*, 8; *Synedra*, 7,360; *Tabellaria*, 1. Infusoria, *Peridinium*, 2. Vermes, *Polyarthra*, 2. Miscellaneous, *Zoöglœa*, 36. Total, 7,431.

North Andover.

The advice of the State Board of Health to the town of North Andover with reference to taking a supply of water for the town from Great Pond may be found on page 44 of this volume. The following analysis of a sample of water from Boston Brook in North Andover was made during an investigation for a new source of water supply for Melrose.

Chemical Examination of Water from Boston Brook, North Andover.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9641	Jan. 25	V. slight.	Slight.	1.70	7.20	3.40	.0042	.0254	.0208	.0046	.39	.0070	.0001	1.6183	2.6

Iron, .0100. Odor, faintly vegetable.——The sample was collected from the brook just below the point where it is crossed by the Salem and Lawrence turnpike, near Boston Hill.

Microscopical Examination.

Diatomaceæ, *Diatoma*, 9; *Meridion*, 8; *Navicula*, 1. Fungi, *Crenothrix*, 1. Total, 19.

Water Supply of Northborough.

Chemical Examination of Water from the Northborough Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10395	May 15	Slight.	Slight.	1.50	3.15	1.55	.0002	.0204	.0186	.0018	.15	.0150	.0001	.9453	0.8
11036	Sept.17	Distinct, green.	Slight.	0.50	4.70	2.05	.0000	.0248	.0200	.0048	.38	.0000	.0000	.6162	1.2
11037	Sept.17	Decided, green.	Cons., yellow.	0.40	4.50	1.95	.0000	.0276	.0156	.0120	.28	.0050	.0000	.4914	0.9
10396	May 15	Slight.	V. slight.	0.90	3.60	1.65	.0000	.0152	.0124	.0028	.12	.0070	.0001	.5913	0.8

Iron in the upper reservoir, .0075; in the lower reservoir, .0130. Odor, vegetable. —— The first two samples were collected from the upper reservoir; the third, from the lower reservoir, and the last from a faucet in the town.

Microscopical Examination of Water from the Northborough Water Works.

[Number of organisms per cubic centimeter.]

	1893.			
	May.	September.	September.	May.
Day of examination,	17	19	19	17
Number of sample,	10395	11036	11037	10396
PLANTS.				
Diatomaceæ,	69	6	2,095	63
Asterionella,	1	0	0	2
Cyclotella,	0	0	28	0
Diatoma,	0	0	200	0
Epithemia,	0	0	1	0
Fragilaria,	2	0	0	0
Gomphonema,	pr.	0	1	0
Melosira,	1	0	260	26
Navicula,	pr.	1	1	0
Pinnularia,	1	0	1	0
Surirella,	0	0	2	0
Synedra,	60	3	1	34
Tabellaria,	4	2	1,600	1
Cyanophyceæ, Nostoc,	1	1	0	0
Algæ,	4	0	21	3
Chlorococcus,	0	0	18	0
Cosmarium,	0	0	0	1
Scenedesmus,	0	0	0	2
Staurastrum,	4	0	0	0
Zoöspores,	pr.	0	3	0
Fungi, Crenothrix,	44	2	0	0

NORTHBOROUGH.

Microscopical Examination of Water from the Northborough Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1893.			
	May.	September.	September.	May.
ANIMALS.				
Rhizopoda, Difflugia,	0	0	1	0
Infusoria,	2	10	37	1
Peridinium,	2	9	36	1
Trachelomonas,	0	1	1	0
Vermes,	0	8	18	0
Anurea,	0	5	12	0
Polyarthra,	0	1	3	0
Rotatorian ova,	0	2	3	0
Crustacea,	0	0	0	.02
Daphnia,	0	0	0	.01
Entomostracan ova,	0	0	0	.01
Miscellaneous, Zoöglœa,	26	2	0	0
TOTAL,	146	29	2,172	67

WATER SUPPLY OF NORTH BROOKFIELD.

Description of Works. — The works are owned by the town and were completed in 1893. The sources of supply are Doane Pond and North Pond, formerly known as Horse Pond, supplemented by water diverted into it from North Brook. Water is pumped by water power at a station near Doane Pond to a distributing reservoir on Bell Hill and thence distributed to the town.

Water can be drawn from either pond, but it is proposed to draw the supply for domestic use from Doane Pond, using the surplus water from Doane Pond, in connection with the water from North Pond, to furnish power for pumping.

NORTH BROOKFIELD.

The areas of watersheds (including the water surfaces) of sources controlled by the town, as determined by actual survey, are as follows:

North Brook,	487.9 acres.
Side Hill Canal from North Brook,	25.0 "
North Pond,	195.6 "
Doane Pond,	899.7 "
Total,	1,608.2 "

The size of the Doane Pond watershed, as given in the table, includes the whole of Stoddard Brook, which has a watershed of 425.8 acres. Provision has been made by which the water of nearly all of this brook can be turned into North Pond when it is desirable to do so.

With the exception of a portion of the watershed of North Brook, which rises in New Braintree, the watersheds of the sources of supply are within the limits of North Brookfield.

North Pond has an area of 69.6 acres and a capacity of about 350,000,000 gallons. It has been used for many years as a storage reservoir to supply power to a mill situated just below Doane Pond. A new dam six feet higher than the old one has been constructed by the town about 500 feet down stream from the old dam, thus greatly increasing the area and storage capacity of the pond. It is said that the pond is thirty feet deep in some places and may average eighteen feet. The water of North Pond is conveyed to the pumping station, situated just below Doane Pond, by means of a canal, without passing through Doane Pond.

Doane Pond is an artificial reservoir constructed many years ago for use as a mill pond. Since its acquisition by the town as a source of water supply the dam has been raised three feet, increasing its area to 30.9 acres and its capacity to 53,800,000 gallons.

A filter entirely surrounded by water has been constructed at Doane Pond near the dam, by building two concentric walls having an annular space five feet wide, filled with gravel, between them. In the centre is a filtered-water well fifteen feet in diameter and fifteen feet deep. Water for the supply of the town is drawn from this well.

The distributing reservoir is rectangular in shape, 159 by 117 feet at the foot of the slopes and 222 by 180 feet at the top of the slopes

inside. It is nineteen feet in depth from the top of the embankments and when filled to a depth of fifteen feet will contain about 2,950,000 gallons of water. The slopes are lined with clay puddle four feet in thickness, covered with a six-inch layer of broken stone, upon which is laid a stone paving one foot in thickness. The bottom is covered with broken stone and binding material to a depth of six inches.

Water enters the reservoir at the bottom on the north side and is drawn out about one foot from the bottom on the south side. An arrangement has been made whereby water may be sprayed into the reservoir from a pipe near its centre. It is intended to pump all water to the distributing reservoir, but a direct connection has been made whereby water may be pumped directly to the town in case of emergency. The distributing mains are of cast-iron.

Chemical Examination of Water from Faucets in North Brookfield, supplied from the North Brookfield Water Works.

[Parts per 100,000.]

Iron, .0433. Odor of the first sample, distinctly vegetable and unpleasant; of the last sample, none.

Microscopical Examination.

No. 10394. Diatomaceæ, *Asterionella*, 8,240, *Tabellaria*, 7. Algæ, *Zoöspores*, 18. Infusoria, *Dinobryon cases*, 9; *Euglena*, 1; *Peridinium*, 76. Miscellaneous, *Zoöglæa*, 3. Total, 8,356.

No. 11038. Diatomaceæ, *Asterionella*, 3,840. Algæ, *Conferva*, 1; *Cosmarium*, 1; *Glœocystis*, 1; *Protococcus*, 80; *Staurastrum*, 1; *Xanthidium*, 1; *Zoöspores*, 1. Infusoria, *Dinobryon cases*, 1. Total, 3,927.

Water Supply of Norwood.

The organism *Uroglena*, which was present in large numbers in the water of Buckmaster Pond in 1892, reappeared in much smaller numbers for a short time in the early part of 1893, and also in very small numbers toward the end of the year. A description of this organism and an account of its effect upon the taste and odor of water may be found in the annual report of the State Board of Health for 1891, pages 645–658.

NORWOOD.

Chemical Examination of Water from Buckmaster Pond, Dedham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9884	Jan. 16	Slight.	Slight.	0.05	2.90	1.15	.0084	.0182	.0156	.0026	.40	.0030	.0000	.2372	0.8
9891	Jan. 18	Distinct.	Slight.	0.05	-	-	-	-	-	-	-	-	-	-	-
9933	Jan. 25	V. slight.	V. slight.	0.05	-	-	-	-	-	-	-	-	-	-	-
9985	Feb. 8	V. slight.	V. slight.	0.05	2.75	0.90	.0140	.0244	.0206	.0038	.44	.0050	.0000	.2263	0.8
10078	Mar. 6	Slight.	Slight.	0.08	2.80	0.80	.0156	.0156	.0118	.0038	.32	.0070	.0001	.1605	0.9
10211	Apr. 4	V. slight.	V. slight.	0.10	2.90	0.80	.0134	.0148	.0136	.0012	.30	.0070	.0000	.2299	0.8
10384	May 10	Slight.	Slight.	0.12	2.55	1.00	.0026	.0184	.0104	.0080	.32	.0080	.0000	.2555	0.5
10479	June 5	Slight.	Slight.	0.15	2.40	0.80	.0004	.0258	.0186	.0072	.31	.0050	.0000	.3525	0.8
10607	July 5	V. slight.	Slight.	0.08	2.45	1.40	.0014	.0240	.0194	.0046	.30	.0000	.0000	.3139	0.5
19750	Aug. 8	Slight.	Slight.	0.05	2.55	1.50	.0000	.0158	.0136	.0022	.36	.0000	.0000	.2146	0.5
10970	Sept. 5	Slight.	Slight.	0.08	2.45	1.20	.0000	.0202	.0142	.0060	.34	.0000	.0000	.3240	0.8
11134	Oct. 2	Slight.	Slight.	0.05	2.75	1.50	.0014	.0150	.0128	.0022	.38	.0000	.0000	.2233	0.5
11291	Nov. 6	V. slight.	V. slight.	0.05	2.35	0.80	.0000	.0284	.0210	.0074	.20	.0030	.0000	.3237	0.5
11448	Dec. 5	V. slight.	Slight.	0.03	2.60	1.05	.0050	.0178	.0150	.0028	.34	.0000	.0003	.1911	0.5
Av.	....	....	....	0.07	2.62	1.08	.0052	.0199	.0156	.0043	.33	.0028	.0000	.2544	0.7

Averages of Analyses of Previous Years.

-	1887*	-	-	0.09	2.64	1.06	.0058	.0212	-	-	.30	.0018	-	-	-
-	1888	-	-	0.15	2.66	0.95	.0069	.0248	-	-	.29	.0065	.0001	-	-
-	1889	-	-	0.11	2.43	0.78	.0025	.0196	.0172	.0024	.30	.0070	.0001	-	-
-	1890	-	-	0.05	2.59	0.99	.0015	.0180	.0147	.0033	.30	.0075	.0000	-	1.0
-	1891	-	-	0.06	2.48	0.97	.0014	.0166	.0140	.0026	.26	.0075	.0000	-	0.7
-	1892	-	-	0.07	2.88	1.24	.0019	.0219	.0172	.0047	.32	.0067	.0000	-	0.7
-	1893	-	-	0.07	2.62	1.08	.0052	.0199	.0156	.0043	.33	.0028	.0000	.2544	0.7

* June to December.

NOTE to analyses of 1893: Iron, .0057. Odor of the first sample, faintly vegetable, becoming faintly oily on standing or on heating; of the second sample, faintly vegetable, becoming strongly oily on heating; of the third sample, none, becoming faintly oily on heating; of the remaining samples, generally faintly vegetable, frequently none, rarely mouldy or grassy.——The samples were collected from the pond generally from five to eleven feet beneath the surface.

NORWOOD.

Microscopical Examination of Water from Buckmaster Pond, Dedham.

[Number of organisms per cubic centimeter.]

	1892.													
	Jan.	Jan.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	17	19	26	9	7	7	12	6	6	10	8	4	8	7
Number of sample,	9884	9891	9933	9985	10078	10211	10384	10479	10597	10750	10970	11134	11291	11448
PLANTS.														
Diatomaceæ,	**58**	**0**	**21**	**pr.**	**8**	**63**	**39**	**917**	**20**	**5**	**40**	**151**	**138**	**26**
Asterionella,	14	0	15	0	8	50	34	228	0	0	31	133	108	21
Cyclotella,	2	0	0	0	0	1	2	610	20	2	2	0	5	3
Melosira,	0	0	0	0	0	2	0	0	0	0	6	15	23	0
Synedra,	1	0	4	0	0	9	pr.	1	pr.	1	1	1	1	2
Tabellaria,	41	0	2	pr.	0	1	3	78	0	2	0	2	1	pr.
Cyanophyceæ,	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**12**	**47**	**0**
Chroöcoccus,	0	0	0	0	0	0	0	0	0	0	0	12	7	0
Microcystis,	0	0	0	0	0	0	0	0	0	0	3	0	40	0
Algæ,	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**57**	**5**	**56**	**9**	**0**	**97**	**0**
Protococcus,	0	0	0	0	0	0	2	57	5	56	5	0	84	0
Raphidium,	0	0	0	0	0	0	2	0	0	0	4	0	13	0
ANIMALS.														
Rhizopoda, Difflugia,	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**8**	**pr.**
Infusoria,	**40**	**0**	**3**	**0**	**1**	**pr.**	**pr.**	**pr.**	**3**	**104**	**20**	**1**	**1,003**	**48**
Dinobryon cases,	38	0	3	0	1	0	0	0	0	0	0	0	1,000	48
Peridinium,	pr.	0	0	0	0	pr.	pr.	pr.	3	104	20	0	pr.	pr.
Trachelomonas,	pr.	0	0	0	0	pr.	0	pr.	0	0	0	1	3	0
Uroglena,	2	0	0	0	0	0	0	0	0	0	0	0	.02	0
Vermes, Anuræa,	**pr.**	**0**	**0**	**0**	**0**	**0**	**0**	**pr.**	**pr.**	**0**	**0**	**0**	**pr.**	**0**
Miscellaneous, Zoöglœa,	**0**	**0**	**0**	**0**	**8**	**3**	**24**	**22**	**12**	**40**	**62**	**144**	**22**	**3**
TOTAL,	98	0	24	pr.	18	66	67	996	40	205	124	308	1,315	77

NORWOOD.

Chemical Examination of Water from Faucets in Norwood, supplied from Buckmaster Pond.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9883	Jan. 16	None.	Slight, earthy.	0.05	2.85	1.20	.0080	.0176	.0154	.0022	.40	.0000	.0000	.2372	0.6
9890	-	V. slight.	V. slight.	0.05	-	-	-	-	-	-	-	-	-	-	-
9934	Jan. 25	V. slight.	None.	0.10	-	-	-	-	-	-	-	-	-	-	-
9986	Feb. 8	None.	None.	0.05	2.60	0.75	.0080	.0172	.0154	.0018	.43	.0050	.0000	.2263	1.1

Iron, .0145. Odor of the first sample, faintly vegetable, becoming distinctly vegetable and oily on heating; of the remaining samples, none, becoming faintly vegetable on heating.

Microscopical Examination of Water from Faucets in the Village of Norwood, supplied from Buckmaster Pond.

[Number of organisms per cubic centimeter.]

	1893.			
	January.	January.	January.	February.
Day of examination,	17	19	26	9
Number of sample,	9883	9890	9934	9986
PLANTS.				
Diatomaceæ,	14	0	3	0
Asterionella,	7	0	3	0
Cyclotella,	3	0	pr.	0
Tabellaria,	4	0	0	0
ANIMALS.				
Infusoria,	40	2	0	0
Dinobryon cases,	40	0	0	0
Uroglena,	0	2	0	0
TOTAL,	54	2	3	0

factory than that from other portions of the works, and to use the surplus water not needed for the supply of the town to furnish power for pumping; but an auxiliary steam plant has been provided at the pumping station for use at times when the supply of water is insufficient to furnish the power needed.

Coolidge Brook is a small tributary of Miller's River from the south which joins the river at a point about one and one-half miles below the village of Orange. The collecting reservoir is located just above the point where the brook is crossed by the Holshire road, about one and three-quarters miles from its mouth. The drainage area of the brook at this point is estimated to be about 1.38 square miles. The reservoir covers an area of about 0.72 acre, and it is said to have a capacity of 2,045,000 gallons when filled to the crest of the overflow, which is three feet below the top of the dam. The loam and sub-soil are said to have been removed from all of the area flowed. The water which passes the overflow is conveyed through a 48-inch pipe two hundred and fifty feet in length and discharged into North Pond.

Provision has been made for filtering the water drawn from Coolidge Brook for the supply of the town, by constructing on the up-stream side of the dam a rectangular filter-chamber of rubble masonry, 10 feet long, 7.5 feet wide, and of a height equal to that of the dam. The filter, which is on the up-stream side, is 5 feet 6 inches in width and of the same height as the walls of the chamber; the filtering material, consisting of sand or gravel, is four feet in thickness, and is retained between perforated wooden planks lined with copper wire screens.

It is the intention to have the top of the chamber closed tightly in order that water may be run back through it under pressure so as to wash the filter. All matter forced out of the filter in this way will mingle with the water in the reservoir. A 10-inch waste pipe is laid beneath the dam to provide for emptying the reservoir when necessary, and to waste the dirty water at times when the filter is being cleaned.

North Pond is located at the head of the middle branch of the Swift River, and originally had an area of about sixty acres. The area and storage capacity of the pond have been greatly increased by the construction of two dams, raising the surface of the pond to

ORANGE.

for shutting off the reservoir from the rest of the system and pumping water directly to the town if necessary. The distributing mains are of cast iron; service pipes are of galvanized iron.

Chemical Examination of Water from Coolidge Brook, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
11396	1893. Nov. 27	None.	V. slight.	0.33	3.80	0.80	.0044	.0140	.0108	.0032	.12	.0070	.0002	.4300	1.2

Iron, .0150. Odor, very faintly vegetable. —— The sample was collected from a faucet in Orange, supplied from Coolidge Brook.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 1.

Chemical Examination of Water from North Pond, Orange.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
11397	1893. Nov. 27	Slight.	Cons.	0.12	2.60	0.75	.0022	.0208	.0152	.0056	.18	.0070	.0001	.3655	1.3

Iron, .0140. Odor, very faintly vegetable. —— The sample was collected from the pond.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 94; *Cocconema*, 1; *Cyclotella*, 13; *Diatoma*, 1; *Epithemia*, 1; *Gyrosigma*, 1; *Melosira*, 292; *Meridion*, 1; *Synedra*, 5; *Tabellaria*, 14. Cyanophyceæ, *Merismopedia*, 10. Algæ, *Conferva*, 1; *Cosmarium*, 1; *Protococcus*, 20; *Raphidium*, 10; *Staurastrum*, 3. Infusoria, *Dinobryon cases*, 3. Vermes, *Anurea*, 1. Crustacea, *Daphnia*, .01. Miscellaneous, *Zoöglœa*, 84. Total, 556.

PALMER.

WATER SUPPLY OF PALMER FIRE DISTRICT, PALMER. — PALMER WATER COMPANY.

Chemical Examination of Water from the Works of the Palmer Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1892.														
10535	June 20	Distinct, clayey.	Cons.	0.30	3.35	1.00	.0004	.0134	.0070	.0064	.10	.0000	.0000	.2345	0.9
10971	Sept. 6	Slight.	Cons.	0.25	4.10	1.30	.0002	.0188	.0134	.0054	.15	.0000	.0001	.3920	1.3

Iron in the first sample, .0235; in the last, .0050 Odor, none. On heating, the odor of the first sample became very faintly vegetable, and of the last decidedly sweetish (grassy). —— The first sample was collected from a faucet in the town; the last, from the reservoir.

Microscopical Examination.

No. 10535. Diatomaceæ, *Diatoma*, 116; *Gomphonema*, 4; *Melosira*, 8; *Navicula*, 1; *Synedra*, 116; *Tabellaria*, 1. Cyanophyceæ, *Merismopedia*, 26. Algæ, *Conferva*, 2; *Cosmarium*, 1; *Glœocapsa*, 8; *Pediastrum*, 2; *Scenedesmus*, 1; *Ulothrix*, 1; *Zoöspores*, 1. Infusoria, *Peridinium*, 24. Miscellaneous, *Zoöglœa*, 84. Total, 394.

No. 10971. Diatomaceæ, *Cocconema*, 1; *Cyclotella*, 1; *Diatoma*, 6; *Melosira*, 24; *Synedra*, 24; *Tabellaria*, 3. Algæ, *Cosmarium*, 1; *Pediastrum*, 3; *Scenedesmus*, 1. Fungi, *Crenothrix*, 2. Infusoria, *Dinobryon cases*, 108; *Peridinium*, 72. Vermes, *Polyarthra*, 1. Miscellaneous, *Zoöglœa*, 64. Total, 311.

PEMBROKE.

Chemical Examination of Water from Little Sandy, Stetson's, Oldham and Furnace Ponds and Silver Lake, Pembroke.

[Parts per 100,000.]

Iron in the first two samples, not determined; in the third, .0065; in the fourth, .0050; in the last, none. Odor of No. 10335, distinctly vegetable; of No. 10336, faintly vegetable, becoming stronger on heating; of No. 10337, none, becoming very faintly vegetable on heating. —— The samples were collected as follows: No. 10330, from Little Sandy Pond at upper end, near road; No. 10331, from Stetson's Pond near its outlet; No. 10335, from the brook flowing from Oldham Pond into Furnace Pond; No. 10336, from Furnace Pond near its outlet; No. 10337, from Silver Lake, north-westerly side, near shore.

The samples were collected in connection with an investigation for an additional water supply for Whitman.

PEMBROKE.

Microscopical Examination of Water from Little Sandy, Stetson's, Oldham and Furnace Ponds and Silver Lake, Pembroke.

[Number of organisms per cubic centimeter.]

	1893.				
	May.	May.	May.	May.	May.
Day of examination,	1	1	1	1	1
Number of sample,	10330	10331	10335	10336	10337
PLANTS.					
Diatomaceæ,	110	111	21	20	195
Asterionella,	2	76	2	5	19
Cocconeis,	0	0	0	1	0
Cocconema,	0	0	0	1	0
Coscinodiscus,	0	1	0	0	0
Cyclotella,	0	32	0	1	6
Fragilaria,	2	0	0	0	0
Grammatophora,	0	0	0	1	0
Melosira,	0	0	0	0	164
Navicula,	2	0	0	1	1
Pleurosigma,	2	0	0	0	0
Stephanodiscus,	0	0	0	0	1
Synedra,	100	0	11	7	2
Tabellaria,	2	2	8	3	2
Cyanophyceæ, Nostoc,	1	0	0	0	0
Algæ,	295	1	1	64	0
Chlorococcus,	2	0	1	5	0
Dictyosphærium,	0	0	0	16	0
Nephrocytium,	0	0	0	6	0
Protococcus,	0	0	0	36	0
Scenedesmus,	1	0	0	0	0
Staurastrum,	0	1	0	0	0
Zoöspores,	292	0	0	1	0
Fungi, Crenothrix,	0	0	0	3	0
ANIMALS.					
Rhizopoda, Actinophrys,	0	0	1	0	0
Infusoria,	69	1	4	3	0
Dinobryon,	0	0	0	1	0
Dinobryon cases,	6	1	2	0	0
Encysted Protozoa,	60	0	0	0	0
Monas,	0	0	1	0	0
Peridinium,	3	0	1	2	0
Vermes,	3	2	1	1	0
Anurea,	3	1	1	1	0
Monocerca,	0	1	0	0	0
Crustacea, Cyclops,	0	0	0	.06	0
Miscellaneous, Zoöglœa,	152	10	12	88	0
TOTAL,	630	125	40	179	195

Water Supply of Plymouth.

In the early part of 1893 the organism *Uroglena*, which was present in considerable numbers in 1892, made its appearance in the water of Little South Pond, and was very abundant in the first part of February. It had entirely disappeared by the end of March and is said not to have been noticed again during the remainder of the year. A description of this organism, and its effect upon the taste and odor of water, was given in the Twenty-third Annual Report of the State Board of Health, pages 645–658.

Chemical Examination of Water from Little South Pond, Plymouth.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
					Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Sus-pended.					
	1893.														
9968	Feb. 6	V. slight.	V. slight.	0.04	2.70	0.60	.0014	.0162	.0142	.0020	.70	.0070	.0001	.1131	0.9
10179	Mar. 27	V. slight.	Slight.	0.00	1.90	0.75	.0000	.0094	.0072	.0022	.59	.0030	.0000	.0766	0.3

Iron, none. Odor of the first sample, distinctly oily, becoming decidedly oily on heating, and strongly oily after standing one day in the laboratory; of the last sample, none. —— The samples were collected from the pond.

Microscopical Examination.

No. 9968. Infusoria, *Uroglena*, very abundant.
No. 10179. Miscellaneous, *Zoöglœa*, 4.

Water Supply of Provincetown.

Population in 1890, 4,624. The works are owned by the town, and were completed in 1893. The supply is taken from a system of six tubular wells located about three-fourths of a mile north of the centre of the village. The wells are five inches in diameter, average twenty-eight feet in depth, and are the same that were used during a pumping test made in 1892. The material in which the wells were sunk is loose sand, which, like other sand in this region, contains more or less organic matter. The extreme wells are about four hundred feet apart in an easterly and westerly direction, and two hundred feet in a northerly and southerly direction. Water from the wells is pumped to a covered iron tank twenty-eight feet in diameter and one hundred feet high, and is distributed thence to the town. In order to aerate the water, the force main is carried vertically up

PROVINCETOWN.

inside the tank to its top, and is provided with a wide flange over which the water falls in a thin sheet. The distributing mains are of cast iron; service pipes of wrought iron lined with cement.

Extended references to the character of this water, which differs from other ground waters in the State, may be found in the annual report of the State Board of Health for 1892, pages 41–44 and 214–218.

Chemical Examination of Water from the Tubular Wells of the Provincetown Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
11266	Oct. 28	Distinct, milky.	Slight.	1.00	8.70	.0030	.0082	1.99	.0000	.0000	.8308	1.1	.1200
11333	Nov. 14	Distinct, fibrous.	V. slight.	1.10	7.30	.0038	.0088	2.36	.0060	.0000	.7719	1.1	.1100
11405	Nov. 27	Decided.	Cons., rusty.	1.00	7.50	.0022	.0092	2.03	.0030	.0002	.7353	1.6	.1560
11481	Dec. 12	Distinct.	Slight, rusty.	0.85	7.10	.0018	.0066	1.95	.0030	.0000	.6320	1.6	.1500
Av.	....	....	....	0.99	7.65	.0027	.0082	2.08	.0023	.0001	.7425	1.4	.1340

Odor, of No. 11405, faintly vegetable; of the remaining samples none; on heating the odor of all the samples was faintly vegetable. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination of Water from the Tubular Wells of the Provincetown Water Works.

	1893. October.	1893. November.	1893. November.	1893. December.
Day of examination,	31	15	29	14
Number of sample,	11266	11333	11405	11481
ANIMALS.				
Infusoria, Monas,	0	1	0	1
Miscellaneous,	290	0	7	0
Iron rust,	260	0	*	*
Zoöglœa,	30	0	7	0
TOTAL,	290	1	7*	1*

* Iron rust very abundant.

QUINCY.

Water Supply of Quincy.

Chemical Examination of Water from Town Brook just above the Storage Reservoir of the Quincy Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9955	Jan. 30	V. slight.	Slight.	0.50	4.55	1.45	.0044	.0154	.0134	.0020	.60	.0280	.0002	.5227	1.4
10059	Feb. 28	None.	V. slight.	0.55	3.80	1.20	.0000	.0098	.0080	.0018	.63	.0300	.0001	.4860	1.1
10193	Mar. 30	Slight.	Slight.	0.70	3.40	1.25	.0032	.0152	.0136	.0016	.49	.0100	.0000	.5256	0.5
10319	Apr. 25	V. slight.	Slight.	0.75	3.55	1.60	.0008	.0148	.0122	.0026	.51	.0050	.0000	.6898	0.3
10450	May 25	V. slight.	Slight.	2.00	4.25	2.10	.0004	.0272	.0250	.0022	.51	.0120	.0000	1.2375	0.8
10561	June 26	V. slight.	Slight.	1.90	5.20	2.90	.0000	.0300	.0252	.0048	.46	.0030	.0000	1.4773	0.5
10697	July 25	V. slight.	V. slight.	0.70	4.45	1.85	.0006	.0164	.0130	.0034	.53	.0050	.0002	1.2728	1.1
10899	Aug. 28	Slight.	Slight.	1.00	5.05	2.15	.0000	.0150	.0135	.0015	.60	.0050	.0001	.7268	0.6
11248	Oct. 23	V. slight.	Slight.	0.80	6.40	2.10	.0008	.0134	.0086	.0048	.68	.0150	.0004	.4104	0.9
11394	Nov. 27	None.	V. slight.	0.50	4.60	1.00	.0056	.0120	.0076	.0044	.69	.0050	.0002	.5375	1.3
11532	Dec. 20	V. slight.	Slight.	0.85	4.55	2.30	.0000	.0160	.0140	.0020	.56	.0030	.0000	.8343	0.8
Av.	....	....	....	0.93	4.58	1.81	.0014	.0168	.0140	.0028	.57	.0110	.0001	.7928	0.8

Averages of Analyses of Previous Years.

-	1887*	-	-	0.50	5.30	1.50	.0000	.0133	-	-	.65	.0080	-	-	-
-	1888†	-	-	0.45	3.64	1.05	.0001	.0122	-	-	.54	.0070	.0003	-	-
-	1889	-	-	1.21	4.61	1.87	.0013	.0239	.0203	.0036	.48	.0073	.0001	-	-
-	1890	-	-	0.73	5.22	2.17	.0024	.0187	.0155	.0032	.52	.0125	.0002	-	1.3
-	1891	-	-	0.72	4.22	1.50	.0004	.0156	.0132	.0024	.49	.0112	.0001	-	0.7
-	1892	-	-	0.87	4.57	1.56	.0041	.0191	.0159	.0032	.55	.0114	.0001	-	0.8
-	1893	-	-	0.93	4.58	1.81	.0014	.0168	.0140	.0028	.57	.0110	.0001	.7298	0.8

* October. † November and December.

NOTE to analyses of 1893; Iron, .0153. Odor, generally distinctly vegetable and often grassy or sweetish, becoming somewhat stronger on heating.——The samples were collected from the brook above the reservoir.

Microscopical Examination.

The greatest number of organisms per cubic centimeter found in any of the samples collected in 1893 was 198, in April; the smallest number, 1, in March; and the average, 62.

QUINCY.

Chemical Examination of Water from the Storage Reservoir, Quincy.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9956	Jan. 30	V. slight.	V. slight.	0.65	5.10	1.90	.0140	.0196	.0172	.0024	.65	.0300	.0001	.5475	1.7
10060	Feb. 28	None.	V. slight.	0.50	4.00	1.60	.0002	.0102	.0074	.0028	.65	.0220	.0000	.5865	1.1
10194	Mar. 30	Slight.	Slight.	0.30	3.30	1.15	.0024	.0130	.0106	.0024	.53	.0150	.0001	.3358	0.5
10318	Apr. 25	Slight.	Cons.	0.45	3.60	1.35	.0028	.0148	.0106	.0042	.52	.0100	.0000	.4270	0.3
10451	May 25	Decided.	Cons.	0.60	3.15	1.60	.0004	.0218	.0184	.0034	.46	.0180	.0000	.5512	0.6
10562	June 26	Decided.	Cons., yellow.	0.80	3.50	1.25	.0010	.0324	.0224	.0100	.60	.0050	.0001	.5727	0.9
10698	July 25	Distinct.	Cons., green.	0.75	3.55	1.50	.0000	.0304	.0248	.0056	.64	.0030	.0001	.5032	0.9
10900	Aug. 28	Decided, green.	Slight, rusty.	0.80	3.95	1.90	.0014	.0238	.0186	.0052	.63	.0000	.0000	.5609	0.6
11094	Sept. 25	Distinct.	Cons., brown.	0.60	3.15	1.25	.0000	.0254	.0218	.0036	.63	.0030	.0001	.5658	0.6
11249	Oct. 23	Distinct.	Cons., green.	0.43	4.70	2.05	.0026	.0244	.0178	.0066	.66	.0050	.0001	.3724	0.8
11395	Nov. 27	Distinct.	Slight.	0.48	3.80	1.25	.0240	.0276	.0214	.0062	.69	.0050	.0003	.5031	0.6
11533	Dec. 20	Slight, clayey.	Slight.	0.40	3.95	1.35	.0140	.0178	.0150	.0028	.65	.0090	.0001	.5362	0.5
Av.	....	....	....	0.56	3.81	1.51	.0052	.0218	.0172	.0046	.61	.0104	.0001	.5052	0.8

Averages of Analyses of Previous Years.

-	1888*	-	-	0.50	3.95	1.18	.0030	.0178	.0132	.0046	.68	.0150	.0003	-	-
-	1889	-	-	0.92	3.76	1.19	.0116	.0303	.0238	.0065	.53	.0087	.0003	-	-
-	1890	-	-	0.70	4.56	1.76	.0085	.0249	.0178	.0071	.54	.0166	.0002	-	1.3
-	1891	-	-	0.70	3.97	1.60	.0027	.0274	.0178	.0096	.50	.0100	.0000	-	0.7
-	1892	-	-	0.62	4.07	1.41	.0051	.0237	.0175	.0062	.61	.0098	.0001	-	0.9
-	1893	-	-	0.56	3.81	1.51	.0052	.0218	.0172	.0046	.61	.0104	.0001	.5052	0.8

* November and December.

NOTE to analyses of 1893; Iron, .0265. Odor, vegetable and occasionally unpleasant or mouldy, becoming somewhat stronger on heating. —— The samples were collected from the reservoir near the surface in the vicinity of the gate-house. Many dead fish came ashore in June.

QUINCY.

Microscopical Examination of Water from the Storage Reservoir, Quincy.

[Number of organisms per cubic centimeter.]

	1893.											
	Feb.	Mar.	Apr.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	2	1	1	27	26	27	26	30	28	25	28	23
Number of sample,	9956	10060	10194	10318	10451	10562	10698	10900	11094	11249	11395	11533
PLANTS.												
Diatomaceæ,	pr.	2	4	133	149	1,105	85	8,001	2,402	3,680	157	1,067
Asterionella,	0	0	0	7	3	24	72	8,000	0	0	18	3
Cyclotella,	0	2	0	52	0	1	0	0	2	0	0	0
Synedra,	pr.	0	pr.	48	24	0	4	0	0	0	128	1,060
Tabellaria,	0	0	4	26	122	1,080	9	1	2,400	3,680	11	4
Cyanophyceæ,	0	0	0	0	36	78	15	100	0	3	0	0
Anabæna,	0	0	0	0	32	60	0	32	0	0	0	0
Clathrocystis,	0	0	0	0	4	18	15	68	0	3	0	0
Algæ,	0	0	14	1	6	296	4	0	0	5	3	65
Pandorina,	0	0	0	0	0	296	0	0	0	0	0	0
Raphidium,	0	0	0	0	0	0	0	0	0	0	3	64
Staurastrum,	0	0	0	1	1	0	3	0	0	4	0	0
Zoöspores,	0	0	14	0	5	0	1	0	0	1	0	1
Fungi, Crenothrix,	pr.	0	0	0	14	0	0	0	0	0	0	0
ANIMALS.												
Rhizopoda,	25	1	1	0	2	3	1	1	1	0	0	0
Actinophrys,	25	1	0	0	0	0	1	1	0	0	0	0
Difflugia,	0	0	1	0	2	3	0	0	1	0	0	0
Infusoria,	58	8	39	9	168	16	221	216	15	12	21	5
Ciliated infusorian,	pr.	0	0	0	2	0	0	0	0	0	1	0
Dinobryon,	0	0	11	0	104	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	0	28	0	0	0	0	0	0	0
Glenodinium,	0	0	0	0	0	0	0	0	0	8	0	0
Monas,	0	0	0	0	1	0	0	0	1	0	0	0
Peridinium,	58	8	28	9	1	2	220	212	11	4	20	5
Synura,	0	0	0	pr.	30	0	0	0	0	0	0	0
Trachelomonas,	0	0	0	0	0	4	1	4	3	0	0	0
Vorticella,	0	0	0	0	2	10	0	0	0	0	0	0
Vermes,	0	pr.	0	pr.	1	0	2	0	0	0	0	0
Polyarthra,	0	0	0	0	0	0	2	0	0	0	0	0
Sacculus,	0	pr.	0	pr.	1	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	3	0	42	170	0	0	460	600	160	128	8	112
TOTAL,	86	11	100	313	376	1,498	788	8,918	2,578	3,828	187	1,269

QUINCY.

Chemical Examination of Water from the Surface and from near the Bottom of the Quincy Storage Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10499	June 8	Distinct.	Cons.	0.60	3.65	1.60	.0000	.0232	.0186	.0046	.69	.0030	.0002	.4924	0.3
10500	June 8	Distinct.	Cons.	0.80	4.00	1.60	.0342	.0260	.0162	.0098	.58	.0050	.0012	.4321	0.6

Iron in the first sample, .0115; in the second sample, .0500. Odor, faintly vegetable, becoming much stronger on heating.——The samples were collected from the reservoir about fifty feet from the gate-house at a point where the water was about thirty feet deep; the first sample was collected near the surface and the last near the bottom.

Microscopical Examination.

No. 10499. Diatomaceæ, *Asterionella*, 16; *Tabellaria*, 240. Cyanophyceæ, *Clathrocystis*, 22; *Cœlosphærium*, 1. Algæ, *Chlorococcus*, 5; *Pediastrum*, 1; *Scenedesmus*, 1; *Staurastrum*, 1; *Zoöspores*, 1. Infusoria, *Dinobryon cases*, 14; *Monas*, 1; *Peridinium*, 2; *Synura*, 7; *Vorticella*, 8. Miscellaneous, *Zoöglœa*, 7. Total, 327.

No. 10500. Diatomaceæ, *Tabellaria*, 4. Fungi, *Crenothrix*, 3. Infusoria, *Dinobryon cases*, 4; *Monas*, 1. Miscellaneous, *Zoöglœa*, 58. Total, 70.

Table showing Heights of Water in the Storage Reservoir of the Quincy Water Works on Dates when Samples of Water were collected for Analysis.

[High-water mark is 86.71 feet above city base.]

1893.	Heights above City Base.	1893.	Heights above City Base.
	Feet.		Feet.
Jan. 30,	83.71	Aug. 28,	83.46
Feb. 28,	86.79	Sept. 25,	81.59
Mar. 30,	86.92	Oct. 28,	79.85
April 25,	86.79	Nov. 27,	79.71
June 26,	86.65	Dec. 20,	81.09
July 25,	84.53		

Water Supply of Randolph and Holbrook.

Chemical Examination of Water from Great Pond in Randolph and Braintree.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1898.														
9932	Jan. 24	Slight.	None.	0.60	4.80	1.56	.0066	.0416	.0278	.0138	.69	.0030	.0000	.6351	1.1
10298	Apr. 24	V. slight.	V. slight.	0.55	3.65	1.10	.0000	.0116	.0098	.0018	.54	.0090	.0001	.4562	0.8
10699	July 26	V. slight.	None.	0.38	4.15	1.80	.0000	.0186	.0156	.0030	.50	.0050	.0000	.4366	1.1
11252	Oct. 25	V. slight.	V. slight.	0.40	6.30	2.90	.0000	.0184	.0172	.0012	.60	.0030	.0000	.4940	0.9
Av.	....	....	....	0.48	4.73	1.84	.0017	.0226	.0176	.0050	.58	.0050	.0000	.5055	1.1

Iron, .0090. Odor of the first two samples distinctly vegetable; of the last two, faintly vegetable. — The first sample was collected directly from Great Pond, the remaining samples from faucets in Randolph and Holbrook.

Microscopical Examination.

The total number of organisms per cubic centimeter found in these samples varied from none to 23 and averaged 7.

Water Supply of Reading.

Chemical Examination of Water from the Filter-gallery of the Reading Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	[redacted]												
9860	Jan. 10	Decided, milky.	Heavy, rusty.	0.50	9.30	.0046	.0056	.62	.0120	[redacted]	.3920	3.5	.1250
9984	Feb. 7	Distinct.	Cons., rusty.	0.65	8.60	.0036	.0134	.52	.0050	.0000	.4599	3.1	.0925
10082	Mar. 5	Decided.	Cons.	0.60	8.80	.0038	.0086	.54	.0120	.0000	.3744	3.3	.1700
10225	Apr. 10	Slight.	V. slight.	0.75	7.10	.0032	.0076	.47	.0080	.0002	.3332	2.5	.0525
10377	May 10	Distinct, milky.	Slight, rusty.	1.00	7.60	.0026	.0102	.44	.0030	.0002	.5110	2.6	.1200
10491	June 7	V. slight.	V. slight.	0.65	[redacted]	.0036	.0120	.49	.0030	.0001	.4891	2.5	.0230
10610	July 5	Slight, milky.	V. slight.	0.55	8.00	.0036	[redacted]	.52	.0000	.0000	.4161	3.1	.0330
10769	Aug. 9	Slight, milky.	V. slight.	0.40	7.80	.0032	.0066	.70	.0000	.0000	.3818	2.2	.0100
11001	Sept. 11	Distinct, milky.	Slight, rusty.	0.50	[redacted]	[redacted]	.0058	.66	.0000	.0001	.1716	3.5	.0450
11156	Oct. 9	Distinct, milky.	Cons.	0.50	9.20	.0034	.0034	.68	[redacted]	[redacted]	.1848	3.1	.0500
11320	Nov. 9	Distinct, milky.	Cons., white.	1.30	22.50	[redacted]	.0154	.56	.0000	.0002	.3071	9.7	.5400
11464	Dec. 5	Distinct, rusty.	Heavy, rusty.	0.30	16.50	.0048	[redacted]	.59	.0000	.0001	.1755	6.7	.2100
Av.	....	....	....	0.64	10.08	.0034	.0067	.56	.0032	.0001	.3497	3.9	.1251

READING.

This water offers a good instance of the effect of a marshy soil on the character of the water percolating through it. The organic matter of the soil consumes the free dissolved oxygen in the water and reduces the insoluble iron salts to the condition of protoxide, so that iron passes into solution in the water. On exposure of the water to the air the iron is again oxidized, forming first a precipitate which gives the water a milky appearance and ultimately settles as a rusty sediment. Conditions in some respects similar to those at Reading are found in Provincetown, Bradford and Watertown, and were found in the test wells at Attleborough (see Twenty-third Annual Report, 1891).

The determinations of turbidity and color in waters of this kind do not have the same significance as in surface waters, but they are, nevertheless, of interest as showing a condition which the water may assume, and are therefore given in the table.

Microscopical Examination of Water from the Filter-gallery of the Reading Water Works.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	12	9	8	12	11	9	8	10	12	10	11	9
Number of sample,	9869	9984	10082	10225	10377	10491	10610	10759	11001	11156	11320	11464
PLANTS.												
Fungi,	*	**4,364**	**0**	**728**	**2,120**	pr.	**6**	**730**	**15,200**	**31**	**76**	**320**
Crenothrix,	*	4,364	0	728	2,120	0	0	730	15,200	31	76	320
Molds,	0	0	0	0	0	pr.	6	0	0	0	0	0
Miscellaneous, Zoöglœa,	**0**	**0**	**17,160**	**0**	**0**	**0**	**0**	**3**	**400**	**80**	**4,000**	**1,360**
TOTAL,	*	4,364	17,160	728	2,120	pr.	6	733	15,600	111	4,076	1,680

* Crenothrix too fine and too abundant to count.

WATER SUPPLY OF REVERE AND WINTHROP. — REVERE WATER COMPANY.

This company obtains part of its supply from wells in Revere and part from wells in Saugus. During the year 1893 there was a sudden and very decided increase in the quantity of chlorine present in the water of the wells located at Revere, as shown by the analyses on the following page, accompanied by a corresponding increase in residue on evaporation and in hardness. This deterioration in the char-

REVERE.

Microscopical Examination of Water from the Wells of the Revere Water Company, at Revere — Concluded.

[Number of organisms per cubic centimeter.]

	1893.						
	Feb.	Apr.	June.	Aug.	Oct.	Nov.	Dec.
ANIMALS.							
Infusoria,	**0**	**0**	**0**	**488**	**0**	**pr.**	**0**
Monas,	0	0	0	40	0	pr.	0
Peridinium,	0	0	0	448	0	0	0
Vermes,	**0**	**0**	**0**	**5**	**0**	**0**	**0**
Anurea,	0	0	0	4	0	0	0
Rotatorian ova,	0	0	0	1	0	0	0
Miscellaneous, Zoöglœa,	**14**	**0**	**0**	**0**	**4**	**8**	**0**
TOTAL,	19	0	0	898	17	10	0

Chemical Examination of Water from Tubular Wells of the Revere Water Company, at Cliftondale, Saugus.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10008	Feb. 13	None.	V. slight.	0.00	10.40	.0000	.0020	1.66	.0480	.0100	.0322	6.8	.0000
10254	Apr. 13	None.	None.	0.00	12.20	.0000	.0012	1.12	.1000	.0125	.0182	5.7	.0040
10525	June 15	V. slight.	Slight.	0.01	13.00	.0004	.0022	1.74	.1000	.0090	.0167	6.1	.0000
10847	Aug. 16	Slight.	Slight.	0.00	14.10	.0010	.0004	1.13	.0750	.0032	.0078	6.7	.0100
11206	Oct. 14	None.	V. slight.	0.00	12.80	.0000	.0000	1.18	.1000	.0065	.0445	6.9	.0080
11496	Dec. 7	None.	None.	0.00	13.10	.0000	.0000	1.11	.1000	.0060	.0320	6.0	.0000
Av.	....	....	....	0.00	12.60	.0002	.0010	1.32	.0872	.0079	.0252	6.4	.0037

Averages of Analyses of Previous Years.

-	1891*	-	-	0.00	11.50	.0018	.0014	0.88	.0100	.0000	-	5.3	-
-	1892	-	-	0.01	11.65	.0000	.0003	1.16	.0123	.0035	-	6.0	.0116
-	1893	-	-	0.00	12.60	.0002	.0010	1.32	.0872	.0079	.0252	6.4	.0037

* September.

NOTE to analyses of 1893: Odor, none. In June a faintly unpleasant odor was developed on heating.—— The samples were collected from a faucet at the pumping station at Cliftondale, Saugus.

Microscopical Examination.

No. 10008. Fungi, *Crenothrix*, 4.
No. 10525. Miscellaneous, *Zoöglœa*, 3.
No organisms were found in the remaining samples.

Water Supply of Salem and Beverly.

The advice of the State Board of Health to the city of Salem, with reference to increasing the joint water supply of Salem and Beverly, by diverting the waters of Longham Meadow Brook and of the brook flowing from Beaver and Norwood's Ponds into Wenham Lake, may be found on page 47 of this volume. Analyses of samples of water collected from the proposed sources are given in the tables on pages 277 and 278.

Chemical Examination of Water from Wenham Lake, in Beverly and Wenham.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9864	Jan. 10	Slight.	Slight.	0.02	5.20	1.00	.0000	.0120	.0104	.0016	.80	.0150	.0000	.1680	2.8
10106	Mar. 9	V. slight.	V. slight.	0.04	5.25	1.60	.0050	.0098	.0084	.0014	.84	.0090	.0001	.0900	2.7
10222	Apr. 7	Distinct, green.	Slight.	0.03	5.05	0.75	.0052	.0158	.0128	.0030	.74	.0100	.0008	.1460	2.3
10356	May 8	Slight.	Slight.	0.03	5.60	1.20	.0016	.0098	.0068	.0030	.75	.0120	.0000	.1423	2.2
10482	June 6	Slight.	Slight.	0.08	5.55	1.35	.0020	.0136	.0112	.0024	.79	.0100	.0000	.2518	2.3
10635	July 10	Slight, green.	Slight.	0.05	5.40	1.90	.0024	.0116	.0100	.0016	.75	.0000	.0000	.1898	2.6
10808	Aug. 15	Distinct.	Slight, green.	0.02	5.00	1.45	.0000	.0172	.0102	.0070	.76	.0000	.0000	.1833	2.6
10996	Sept. 9	Slight.	Slight, green.	0.02	5.55	1.35	.0022	.0148	.0104	.0044	.75	.0000	.0000	.1826	2.6
11135	Oct. 4	Slight.	Slight.	0.05	5.85	1.00	.0024	.0116	.0102	.0014	.76	.0000	.0000	.1540	2.7
11289	Nov. 6	Slight.	Slight.	0.03	5.75	1.00	.0096	.0156	.0114	.0042	.77	.0080	.0001	.1950	2.9
11455	Dec. 6	Slight.	Slight.	0.03	6.20	1.25	.0060	.0112	.0078	.0034	.76	.0020	.0001	.1131	2.7
Av.	....	....	....	0.04	5.49	1.26	.0033	.0130	.0100	.0030	.77	.0055	.0001	.1605	2.6

Averages of Analyses of Previous Years.

-	1887*	-	-	0.05	4.73	0.82	.0025	.0135	-	-	.72	.0019	-	-	-
-	1888	-	-	0.05	4.67	0.97	.0020	.0146	-	-	.73	.0058	.0001	-	-
-	1889	-	-	0.06	4.23	1.06	.0014	.0173	.0138	.0035	.72	.0052	.0002	-	-
-	1890	-	-	0.05	4.57	0.90	.0016	.0154	.0125	.0029	.74	.0104	.0001	-	2.5
-	1891	-	-	0.07	4.70	1.12	.0006	.0147	.0113	.0034	.72	.0125	.0000	-	1.9
-	1892	-	-	0.03	4.85	1.10	.0016	.0137	.0103	.0034	.75	.0077	.0000	-	2.2
-	1893	-	-	0.04	5.49	1.26	.0033	.0130	.0100	.0030	.77	.0055	.0001	.1605	2.6

* June to December.

Note to analyses of 1893: Iron, .0052. Odor, vegetable and frequently unpleasant, becoming stronger on heating and sometimes mouldy.——The first two samples were collected from faucets at the pumping station; the remaining samples from the lake near the inlet pipe of the Salem Water Works.

SALEM AND BEVERLY.

Table showing Heights of Water in Wenham Lake at Times when Samples of Water were collected for Analysis.

[NOTE. — High-water mark is 30.17 feet.]

Date.	Height of Water.	Date.	Height of Water.
1893.	Feet.	1893.	Feet.
Jan. 10, ...	20.92	Aug. 15, ...	23.35
Mar. 9, ...	20.96	Sept. 9, ...	22.77
Apr. 7, ...	22.69	Oct. 4, ...	22.00
May 8, ...	23.87	Nov. 6, ...	21.58
June 6, ...	24.67	Dec. 6, ...	21.33
July 10, ...	24.31		

Chemical Examination of Water from Beaver Pond, Norwood's Pond, and Longham Meadow Brook, in Beverly.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10072	Mar. 1	Slight.	Cons.	1.20	5.10	2.00	.0102	.0218	.0180	.0038	.80	.0030	.0002	.5983	1.3
10073	Mar. 1	Slight.	Slight.	1.40	5.50	2.40	.0098	.0224	.0196	.0028	.70	.0030	.0002	1.0764	1.3
10074	Mar. 1	Slight.	Cons., brown.	1.50	7.05	2.65	.0036	.0328	.0300	.0028	1.00	.0150	.0002	1.1304	2.2
10132	Mar. 15	Slight.	Slight.	0.70	4.25	1.70	.0086	.0162	.0140	.0022	.62	.0070	.0000	.6201	1.3
10133	Mar. 15	Slight, clayey.	Slight, earthy.	0.50	3.25	1.85	.0056	.0210	.0164	.0046	.43	.0000	.0000	.6238	0.9

Iron in the first sample, .0650; in the next two, .0500 each; in the fourth, .0600; in the last, .0150. Odor of the first three samples distinctly vegetable and of the first one also disagreeable. Of the last two samples, No. 10132 had a very faintly vegetable odor and No. 10133 none.——Nos. 10072 and 10132 were collected from the brook flowing from Norwood's Pond; No. 10073, from the brook flowing from Beaver Pond; Nos. 10074 and 10133, from Longham Meadow Brook just above the point where it is joined by the brook flowing from Norwood's Pond.

SALEM AND BEVERLY.

Microscopical Examination of Water from Beaver Pond, Norwood's Pond, and Longham Meadow Brook, in Beverly.

[Number of organisms per cubic centimeter.]

	1893.				
	March.	March.	March.	March.	March.
Day of examination,	3	3	3	17	17
Number of sample,	10072	10073	10074	10132	10133
PLANTS.					
Diatomaceæ,	0	2	5	3	17
Fragilaria,	0	0	0	2	4
Navicula,	0	0	1	pr.	5
Synedra,	0	pr.	3	1	6
Tabellaria,	0	2	1	0	2
Cyanophyceæ, Nostoc spores,	0	0	0	1	0
Algæ, Zoöspores,	2	0	0	2	0
Fungi,	0	0	18	2	0
Beggiatoa,	0	0	0	2	0
Cladothrix,	0	0	18	0	0
ANIMALS.					
Infusoria,	3	8	0	9	2
Dinobryon,	0	1	0	4	2
Peridinium,	3	7	0	5	0
Miscellaneous, Zoöglœa,	2,000	70	2	180	58
TOTAL,	2,005	80	25	197	77

WATER SUPPLY OF SAUGUS.

(See *Lynn.*)

SCITUATE.

The advice of the State Board of Health with reference to taking a water supply for the village of Scituate Harbor in the town of Scituate, from the ground in the vicinity of Satuit Brook, may be found on page 50 of this volume. An analysis of a sample of water from the flowing test well, referred to in the communication of the Board, is given below.

SCITUATE.

Chemical Examination of Water from a Tubular Test Well in Scituate.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
10017	1893. Feb. 14	None.	None.	0.02	8.35	.0006	.0010	1.74	.0800	.0000	.0472	3.1	.0000

Odor none.——The sample was collected from a flowing test well in a meadow near Willow Street about three hundred feet east of the railroad.

Microscopical Examination.

No organisms.

Water Supply of Sharon. — Sharon Water Company.

The reply of the State Board of Health to an application of the Board of Health of Sharon for advice with reference to the possible pollution of the water supply of the town under existing conditions, and as to the best practicable method of assuring its purity in the future, may be found on page 51 of this report.

Chemical Examination of Water from the Well of the Sharon Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
10941	1893. Aug. 31	None.	None.	0.0	10.70	.0000	.0000	.91	.3750	.0000	.0158	2.8	.0100

Odor, none.——The sample was collected from a faucet at the pumping station.

Microscopical Examination.

No organisms.

Water Supply of Somerville.

(See *Boston, Mystic Works.*)

Water Supply of Southbridge. — Southbridge Water Supply Company.

The advice of the State Board of Health to the Southbridge Water Supply Company relative to increasing its supply by the

construction of an additional storage reservoir about one mile south of the present upper reservoir, and as to improving the existing supply; also, at a subsequent date, with reference to increasing its supply by taking water from a proposed storage reservoir on Hatchet Brook, may be found on pages 51–53 of this volume. Analyses of samples of water collected from the present sources of supply and from Hatchet Brook and its tributaries are given in the following tables.

Chemical Examination of Water from the Lower Reservoir of the Southbridge Water Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Sus-pended.					
	1898.														
11082	Sept. 15	Decided.	Cons.	0.15	3.75	1.65	.0052	.0554	.0176	.0378	.22	.0030	.0002	.3042	1.6

Iron, .0160. Odor, none, becoming distinctly vegetable and grassy on heating. —— The sample was collected from the lower reservoir at a time when it was nearly empty.

Microscopical Examination.

Diatomaceæ, *Cyclotella*, 168; *Cymbella*, 1; *Diatoma*, 260; *Epithemia*, 1; *Gomphonema*, 3; *Navicula*, 2; *Pinnularia*, 4; *Surirella*, 2; *Synedra*, 160; *Tabellaria*, 92. Algæ, *Arthrodesmus*, 1; *Pediastrum*, 7; *Scenedesmus*, 5; *Staurogenia*, 4. Infusoria, *Euglena*, 112; *Monas*, 2; *Peridinium*, 48. Vermes, *Anurea*, 1; *Polyarthra*, 2. Miscellaneous, *Zoöglœa*, 60. Total, 935.

Chemical Examination of Water from Glover Spring, Southbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albu-minoid.		Nitrates.	Nitrites.			
	1898.												
11083	Sept. 14	None.	None.	0.00	10.75	.0000	.0002	.80	.4000	.0001	.1260	6.8	.0076
11256	Oct. 26	V. slight.	V. slight.	0.06	12.90	.0000	.0050	[illegible]	.4350	.0000	.0190	3.9	[illegible]

Odor of the first sample, none; of the second sample, distinctly unpleasant, disappearing on heat-

SOUTHBRIDGE.

Chemical Examination of Water from Hatchet Brook and one of its Tributaries in Southbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
11031	Sept. 14	V. slight.	V. slight.	0.10	4.65	0.80	.0000	.0042	.0030	.0012	.21	.0000	.0000	.1404	1.7
11256	Oct. 26	V. slight.	Slight.	1.50	8.05	3.60	.0000	.0242	.0214	.0028	.38	.0000	.0000	1.2616	1.9
11358	Nov. 20	Slight.	Slight.	0.30	4.25	1.25	.0000	.0118	.0106	.0012	.20	.0050	.0000	.5208	1.4
11359	Nov. 20	None.	V. slight.	0.50	4.65	1.40	.0006	.0128	.0110	.0018	.20	.0000	.0000	.6762	1.4
Av.	....	....	....	0.60	5.40	1.76	.0002	.0133	.0115	.0018	.25	.001[illegible]	.0000	.6498	1.6

Iron in the first sample, .0060; in the second, .0070; in the third, .0050; in the last, .0020. Odor of the first sample, none; of the remaining samples, very faintly vegetable, becoming stronger on heating. — The first sample was collected from Hatchet Brook at a road crossing about three-fourths of a mile from its mouth; the second and last samples, from the brook at site of proposed dam of the Southbridge Water Company, about half a mile above the point where the first sample was collected; the third sample, from a small tributary which enters Hatchet Brook from the west, about half a mile above the site of the proposed dam.

Microscopical Examination of Water from Hatchet Brook in Southbridge.

[Number of organisms per cubic centimeter.]

	1893.			
	September.	October.	November.	November.
Day of examination,	16	28	22	22
Number of sample,	11031	11256	11358	11359
PLANTS.				
Diatomaceæ,	3	1	4	3
Meridion,	0	0	2	1
Synedra,	0	1	2	2
Tabellaria,	3	0	pr.	0
Fungi, Crenothrix,	230	27	22	7
ANIMALS.				
Vermes, Anurea,	0	1	0	0
Miscellaneous, Zoöglœa,	0	3	14	1
Total,	233	32	40	11

SOUTHBRIDGE.

Chemical Examination of Water from Hatchet Pond in Woodstock, Conn., just South of the Boundary between Massachusetts and Connecticut.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
11257	Oct. 26	Slight.	Slight.	0.15	2.10	0.65	.0000	.0142	.0102	.0040	.16	.0000	.0000	.3192	0.5
11360	Nov. 20	Slight.	Slight.	0.02	2.10	0.70	.0022	.0148	.0126	.0022	.15	.0050	.0000	.2520	0.8

Iron, .0025. Odor of the first sample, faintly vegetable, becoming distinctly vegetable and unpleasant on heating; of the second sample, very faintly vegetable, disappearing on heating.——The samples were collected from the pond which is located at the head of Hatchet Brook.

Microscopical Examination.

No. 11257. Diatomaceæ, *Synedra*, 1. Cyanophyceæ, *Anabæna*, 4; *Cœlosphærium*, 1; *Merismopedia*, 480. Algæ, *Chlorococcus*, 10. Fungi, *Crenothrix*, 38. Miscellaneous, *Zoöglœa*, 4. Total, 538.

No. 11360. Diatomaceæ, *Navicula*, 1. Cyanophyceæ, *Merismopedia*, 19. Algæ, *Protococcus*, 2; *Raphidium*, 2. Total, 24.

Water Supply of South Hadley Falls Fire District, South Hadley.

Chemical Examination of Water from a Faucet in South Hadley, supplied from Buttery Brook Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
11558	Dec. 27	Slight.	Slight.	0.10	3.20	0.90	.0008	.0030	.0014	.0016	.15	.0250	.0000	.1309	0.8

Iron, .0125. Odor, none, becoming faintly vegetable on heating.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 14.

WATER SUPPLY OF SPENCER.

Chemical Examination of Water from Shaw Pond, Leicester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1898.														
9994	Feb. 8	V. slight.	V. slight.	0.05	2.85	0.85	.0048	.0202	.0148	.0054	.22	.0070	.0001	.1131	1.1
10174	Mar. 27	Slight.	Slight.	0.02	1.55	0.45	.0034	.0086	.0060	.0026	.12	.0050	.0001	.0912	0.5
10315	Apr. 26	None.	None.	0.02	1.90	0.40	.0000	.0060	.0038	.0022	.13	.0070	.0000	.1058	0.3
10387	May 14	None.	V. slight.	0.03	2.05	0.35	.0004	.0084	.0066	.0018	.11	.0030	.0000	.0803	0.9
10789	Aug. 13	V. slight.	V. slight.	0.03	3.00	1.10	.0004	.0136	.0102	.0034	.14	.0000	.0000	.1382	1.0
10961	Sept. 4	Slight.	Slight.	0.05	2.25	0.60	.0018	.0192	.0166	.0026	.14	.0030	.0000	.1480	0.7
Av.	....	....	....	0.03	2.27	0.63	.0018	.0127	.0097	.0030	.14	.0042	.0000	.1128	0.8

Iron, .0033. Odor of the first four samples, faintly vegetable; of the last two samples, none. —— The first two samples and the last were collected from the pond; the remaining samples, from a faucet in the town.

Microscopical Examination of Water from Shaw Pond, Leicester.

[Number of organisms per cubic centimeter.]

	1898.					
	Feb.	March.	April.	May.	Aug.	Sept.
Day of examination,	11	29	27	16	15	6
Number of sample,	9994	10174	10315	10387	10789	10961
PLANTS.						
Diatomaceæ,	**3**	**4**	**5**	**1**	**14**	**28**
Asterionella,	0	0	4	0	0	14
Melosira,	1	0	0	0	14	13
Synedra,	2	4	1	1	0	1
Algæ,	**0**	**0**	**0**	**0**	**106**	**60**
Botryococcus,	0	0	0	0	0	60
Protococcus,	0	0	0	0	106	0

Microscopical Examination of Water from Shaw Pond, Leicester—Concluded.

and a considerable depth. It has no visible inlet or outlet and is supplied with water which percolates into it from the sandy territory by which it is surrounded. The lowering of the water in the pond by pumping doubtless makes available a considerable quantity of water stored in the ground about it. Between Aug. 7 and Oct. 28, 1893, a total of 164,000,000 gallons of water were pumped from this source. An analysis of the water of Chapin Pond is given with the analyses of samples of water from the other sources of supply in the tables below.

Chemical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.

[Parts per 100,000.]

Iron, .0102. Odor, generally distinctly vegetable, frequently grassy, sometimes none. In September the odor was strongly vegetable and mouldy. —— The samples were collected from the basin in the vicinity of the gate-house. When the September and October samples were collected water was being pumped into this basin from Ludlow Reservoir.

SPRINGFIELD.

Microscopical Examination of Water from the Receiving Basin of the Springfield Water Works, at Ludlow.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	11	9	8	8	10	9	7	17	8	5	10	7
Number of sample,	9856	9979	10091	10216	10370	10489	10605	10835	10974	11140	11298	11444
PLANTS.												
Diatomaceæ,	6	7	4	13	903	49	350	47	53	180	28	24
Asterionella,	0	0	0	8	870	1	0	0	0	0	5	0
Cyclotella,	2	pr.	0	0	1	1	88	4	32	0	1	0
Diatoma,	0	1	pr.	0	0	0	0	2	0	0	0	4
Fragilaria,	0	0	2	0	0	2	15	8	0	1	0	0
Melosira,	0	1	1	1	27	11	240	26	20	64	16	0
Meridion,	0	2	pr.	2	pr.	1	0	0	0	1	0	3
Navicula,	3	pr.	1	1	pr.	7	0	1	0	2	1	3
Pinnularia,	0	0	0	0	1	1	0	2	0	0	0	1
Synedra,	1	3	pr.	5	3	24	1	3	1	112	5	10
Tabellaria,	0	pr.	0	1	1	1	6	1	0	0	0	3
Cyanophyceæ,	0	0	0	pr.	0	1	64	13	280	128	4	0
Anabæna,	0	0	0	pr.	0	0	64	2	200	44	0	0
Anabæna spores,	0	0	0	0	0	0	0	0	80	0	0	0
Chroöcoccus,	0	0	0	0	0	1	0	11	0	0	0	0
Merismopedia,	0	0	0	0	0	0	0	0	0	84	4	0
Algæ,	0	16	pr.	5	5	2	10	31	0	317	18	0
Chlorococcus,	0	0	0	pr.	0	0	0	15	0	244	0	0
Closterium,	0	16	pr.	5	2	0	0	0	0	0	0	0
Nephrocytium,	0	0	0	0	0	0	0	8	0	0	0	0
Protococcus,	0	0	pr.	0	2	0	4	8	0	0	12	0
Raphidium,	0	0	0	0	0	0	0	0	0	5	5	0
Scenedesmus,	0	0	0	0	0	2	1	0	0	68	1	0
Zoöspores,	0	0	0	0	1	0	5	0	0	0	0	0
Fungi, Crenothrix,	9	0	0	pr.	0	0	0	0	0	9	7	0
ANIMALS.												
Infusoria,	22	39	3	1	2	125	1	42	0	4	22	1
Dinobryon,	8	0	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	0	0	0	0	124	0	0	0	0	20	0
Monas,	0	1	0	0	1	pr.	0	1	0	1	2	1
Peridinium,	14	38	3	1	1	0	1	40	0	2	0	0
Trachelomonas,	0	0	0	pr.	0	1	0	1	0	1	0	0
Miscellaneous, Zoöglœa,	32	74	2	0	24	100	36	68	36	160	40	72
TOTAL,	69	136	9	19	934	277	461	201	369	798	119	97

SPRINGFIELD.

Chemical Examination of Water from Ludlow Reservoir.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10398	May 15	Decided.	Heavy, earthy & floccul't.	0.85	3.00	1.25	.0032	.0194	.0148	.0046	.08	.0030	.0002	.5256	0.8
10488	June 6	Distinct, white.	Cons., white.	0.45	3.30	1.05	.0044	.0230	.0172	.0058	.18	.0030	.0001	.5402	1.3
10604	July 5	Decided, green.	Heavy, green.	0.80	4.85	2.25	.0000	.0526	.0348	.0178	.11	.0030	.0000	.7008	1.1
10834	Aug. 16	Decided, green.	Slight, yellow.	0.45	6.55	3.95	.0002	.0522	.0300	.0222	.13	.0030	.0000	.7176	1.3
10975	Sept. 7	Decided, green.	Cons., yellow.	0.50	4.90	3.00	.0004	.0532	.0422	.0110	.13	.0030	.0001	.7320	1.6
11141	Oct. 4	Slight.	Cons., green.	0.30	3.50	1.75	.0000	.0384	.0260	.0124	.12	.0000	.0000	.4928	1.1
11299	Nov. 7	Distinct.	Cons., green.	0.28	3.70	1.80	.0008	.0344	.0220	.0124	.19	.0000	.0001	.5160	1.3
11445	Dec. 5	Slight.	Slight.	0.15	3.05	1.20	.0000	.0270	.0204	.0066	.17	.0000	.0002	.3978	0.9
Av..	....	....	....	0.47	4.11	2.03	.0011	.0875	.0259	.0116	.14	.0019	.0001	.5779	1.2

Averages of Analyses of Previous Years.

-	1876-77*	-	-	-	4.86	-	.0139	.0426	.0296	.0130	-	-	-	-	-
-	1887†	-	-	0.24	3.63	1.65	.0030	.0486	-	-	.15	.0019	-	-	-
-	1888	-	-	0.13	2.91	1.20	.0019	.0332	-	-	.12	.0047	.0001	-	-
-	1889	-	-	0.11	2.42	1.07	.0028	.0461	.0237	.0224	.10	.0033	.0002	-	-
-	1890	-	-	0.15	2.96	1.54	.0029	.0387	.0210	.0177	.10	.0065	.0001	-	0.9
-	1891	-	-	0.31	3.27	1.20	.0011	.0225	.0147	.0078	.09	.0049	.0001	-	1.0
-	1892‡	-	-	0.25	3.41	1.41	.0006	.0277	.0189	.0088	.13	.0049	.0001	-	1.0
-	1893§	-	-	0.47	4.11	2.03	.0011	.0375	.0259	.0116	.14	.0019	.0001	.5779	1.2

* These analyses were made by Prof. William R. Nichols, for the city of Springfield, from samples collected about once a week, between July 1, 1876, and Sept. 30, 1877.

† June to December. ‡ January to September. § May to December.

NOTE to analyses of 1893; Iron, .0133. Odor, vegetable, rarely mouldy or unpleasant; on heating the odor is generally stronger.——The samples were collected from the reservoir at depths of one to six feet beneath the surface, generally near the outlet. In July and August the samples were collected near the center of the reservoir.

This reservoir was empty at the beginning of the year and began to fill again on May 9. For record of heights of water on dates when samples of water were collected for analysis, see page 289.

SPRINGFIELD.

Table showing Heights of Water in Ludlow Reservoir at times when Samples of Water were collected for Analysis in 1893.

NOTE.— Height of rollway, 33 1 feet above bottom of reservoir.

Date.	Height of Water above Bottom of Reservoir.	Date.	Height of Water above Bottom of Reservoir.
1893.	Feet.	1893.	Feet.
May 15,	10.00	Sept. 7,	14.50
June 6,	11.00	Oct. 4,	14.00
July 5,	14.50	Nov. 7,	14.70
Aug. 16,	14.65	Dec. 5,	15.50

NOTE — The height of water in this reservoir in previous years has been given with reference to the bottom of the main pipe leading to the city, which is twenty-three feet below the rollway and 10.1 feet higher than the bottom of the reservoir at the dam.

Chemical Examination of Water from Chapin Pond, Ludlow.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1893.														
11531	Dec. 20	V. slight.	V. slight.	0.01	3.20	0.75	.0114	.0110	.0090	.0020	.12	.0030	.0000	.1863	0.6

Iron, .0025. Odor, unpleasant.—— The sample was collected from the pond fifty feet from shore and three feet beneath the surface.

Microscopical Examination.

Algæ, *Scenedesmus*, 420.

Water Supply of Stockbridge — Stockbridge Water Company.

Chemical Examination of Water from Lake Averic, Stockbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Sus-pended.		Nitrates.	Nitrites.		
	1893.														
10421	May 20	Slight.	Slight.	0.08	5.85	1.20	.0242	.0134	.0112	.0022	.06	.0120	.0060	.0487	3.9
[illegible]	Aug. 22	Slight.	Slight.	0.05	6.25	1.60	.0028	.0192	.0156	.0036	.07	.0050	.0000	.3555	4.1
11364	Nov. 21	V. slight.	Slight.	0.05	6.35	1.55	.0006	.0170	.0144	.0026	.08	.0030	.0000	.3696	4.3
Av.	....	....	....	0.06	6.15	1.45	.0092	.0165	.0137	.0028	.07	.0067	.0020	.2579	4.1

Iron, .0069. Odor, of the first sample, none, becoming distinctly vegetable on heating; of the second and last samples, distinctly vegetable and unpleasant; of the third sample, faintly vegetable. The odors of the last three samples were unchanged by heating.—— The first and last samples were collected from faucets in the pumping station, and represent water from the lake; the second sample, directly from the lake near the pumping station.

Microscopical Examination of Water from Lake Averic, Stockbridge.

[Number of organisms per cubic centimeter.]

	1893.		
	May.	Aug.	Nov.
Day of examination,	23	25	22
Number of sample,	10421	10986	11344
PLANTS.			
Diatomaceæ,	1	1	106
Asterionella,	0	0	96
Fragilaria,	0	0	4
Navicula,	0	pr.	2
Synedra,	1	1	4
Algæ, Protococcus,	0	4	0
Fungi, Crenothrix,	532	0	0
ANIMALS.			
Infusoria,	28	21	306
Dinobryon,	0	0	200
Dinobryon cases,	0	0	100
Peridinium,	0	18	6
Trachelomonas,	28	3	0
Vermes, Anurea,	0	0	2
Miscellaneous, Zoöglœa,	0	6	0
TOTAL,	561	32	406

Water Supply of Stoneham.

(See *Wakefield.*)

Water Supply of Stoughton.

Description of Works. — Population in 1890, 4,852. The works of the Stoughton Water Company, from which the town was formerly supplied, were purchased by the town in June, 1892, and new works for taking water from another source were completed by the town in 1893.

The new source of supply is a well located near Muddy Pond Brook, about a quarter of a mile below Muddy Pond and about a mile and a half in a south-westerly direction from the centre of the village of Stoughton, supplemented by water taken from the brook

near the well. The watershed of the brook, above a point opposite the well, has an area, as measured from the State map, of 1.83 square miles. Of this area, fully one-third contributes to the supply of Muddy Pond. This portion of the watershed is an elevated and generally level gravelly tract, which contains a great many depressions from which there is no outlet, and the portion of the rainfall which is not evaporated sinks into the ground and reappears in and around Muddy Pond in the form of springs. The remainder of the watershed drains through Leonard Brook and enters Muddy Pond Brook a short distance below the pond.

The pond is about three hundred feet in diameter and is surrounded by swampy land, at the edge of which most of the springs appear.

The well is six feet in diameter and is said to be thirty-nine feet in depth. It is lined with brick work, the portion near the bottom being laid without mortar. Just below the well a puddle cut-off wall was constructed across the valley of the brook, two hundred and forty feet in length and forty feet in depth. The excavation for this wall is said to have been through six feet of clay, thirty to thirty-two feet of gravel, and two to four feet of hard pan. On the upper side of the wall, just above the hard pan, six lines of four-inch tile pipes were laid to the collecting well. Between the well and Muddy Pond, at a point five hundred to six hundred feet above the well, a dam was constructed to flow an area of 34.3 acres to an elevation about twelve feet above the level of the brook at the collecting well. The pond and swampy land before mentioned were included in the area to be flowed. It was thought that this reservoir would increase the supply from the well, but as it was found upon trial that it did not, and the water was of such character that it was not suitable for use if taken directly from the reservoir, it was abandoned.

From the collecting well a twelve-inch cast-iron pipe, 4,263 feet in length, conveys the water to a pump well at the pumping station, which is located on the right or easterly bank of the brook, just above Central Street. The pipe is turned down at both ends and was intended to act as a siphon when the water in the collecting well was lower than the pipe. The pump well is a water-tight wrought iron tank, six feet in diameter and twenty-six feet in depth, and from it water is pumped to the town and to the open iron tank formerly used in connection with the old source of supply.

STOUGHTON.

With a view to filtering the water taken from the brook, a small filter, having an area of about one hundred square feet, was constructed near the collecting well. The filter contains five feet in depth of sand and gravel of various degrees of fineness, the coarser material being at the bottom of the filter and the finer at the top. Water from the brook can be turned upon the filter to a maximum depth of two feet.

After it was found that the collecting well would not furnish enough water for the town, application was made to the State Board of Health for advice relative to taking a new source or devising some method of obtaining a larger supply from the present plant. The reply of the Board to this application may be found on page 55 of this volume.

Chemical Examination of Water from the Stoughton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
11547	1893. Dec. 25	V. slight.	Slight.	0.70	4.05	1.95	.0024	.0116	.0084	.0032	.36	.0200	.0001	.6720	0.6

Iron, .0065. Odor, distinctly vegetable. —— The sample was collected from a faucet at the pumping station, at a time when water was being taken from the brook.

Microscopical Examination.

Diatomaceæ, *Meridion*, 1; *Pinnularia*, 1; *Synedra*, 20. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 3. Total, 28.

Water Supply of Swampscott and Nahant — Marblehead Water Company.

The great variation in the quantities of chlorine, total residue, and hardness in this water, is due to the presence of a small quantity of sea water, at times, in the water of some of the wells from which the supply of this company is drawn.

SWAMPSCOTT AND NAHANT.

Chemical Examination of Water from the Wells of the Marblehead Water Company, Swampscott.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9861	Jan. 9	None.	None.	0.00	39.80	.0000	.0028	11.08	.5000	.0000	.0400	12.4	.0010
9991	Feb. 8	None.	None.	0.00	43.50	.0000	.0026	11.00	.4250	.0001	.0547	11.6	.0000
10104	Mar. 8	None.	None.	0.00	28.90	.0000	.0006	6.30	.4500	.0000	.0252	13.6	.0040
10226	Apr. 11	Slight.	V. slight.	0.12	9.20	.0002	.0052	1.60	.1000	.0000	.2299	3.6	.0120
10378	May 9	None.	Slight.	0.03	18.70	.0000	.0040	2.98	.2500	.0000	.0547	8.1	.0000
10494	June 7	None.	None.	0.00	46.80	.0000	.0026	11.60	.4000	.0001	.0657	12.4	.0070
10606	July 6	None.	None.	0.00	52.00	.0000	.0012	13.24	.3500	.0000	.0803	5.9	.0000
10767	Aug. 10	None.	None.	0.00	74.30	.0000	.0000	20.60	.7500	.0000	.0632	13.4	.0100
10997	Sept. 10	None.	None.	0.00	76.80	.0000	.0022	19.84	.7000	.0000	.0858	17.2	.0050
11175	Oct. 9	None.	None.	0.00	70.20	.0000	.0012	20.84	.7000	.0000	.0972	30.6	.0100
11313	Nov. 8	V. slight.	V. slight.	0.02	52.40	.0000	.0018	14.61	.0900	.0002	.0760	25.4	.0120
11457	Dec. 6	Slight.	V. slight.	0.00	44.40	.0000	.0022	11.80	.4000	.0000	.0234	21.8	.0120
Av.	....	....	....	0.01	46.42	.0000	.0022	12.12	.4263	.0000	.0747	14.7	.0061

Averages of Analyses of Previous Years.

-	1887*	-	-	0.03	23.88	.0032	.0028	2.94	.5302	-	-	-	-
-	1888	-	-	0.00	25.16	.0007	.0035	3.26	.4477	.0003	-	-	-
-	1889†	-	-	0.00	26.20	.0006	.0033	3.80	.4390	.0002	-	-	-
-	1890‡	-	-	0.00	44.00	.0006	.0010	8.30	.6250	.0001	-	21.2	-
-	1891	-	-	0.00	38.64	.0018	.0010	7.73	.9909	.0002	-	18.0	-
-	1892	-	-	0.00	54.94	.0000	.0010	14.53	.7437	.0000	-	22.0	-
-	1893	-	-	0.01	46.42	.0000	.0022	12.12	.4263	.0000	.0747	14.7	.0061

* June to December. † January to May. ‡ October.

NOTE to analyses of 1893; Odor, of No. 10226, faintly earthy; of No. 10378, faintly disagreeable, becoming fainter on heating; of the remaining samples, none. —— The samples were collected from a faucet at the pumping station.

Microscopical Examination.

A very few organisms were found in the samples collected in April, May, June, October and November. In the remaining samples no organisms were found.

TAUNTON.

Provision has been made at the pumping station for conveying the water of Elder's Pond directly to the pumps, to the filter-basin or to the old twenty-inch force main leading to the city. By means of the connection last mentioned water could be supplied under a light pressure to portions of the city by gravity in the event of any accident to the pumps. A twenty-inch blow-off discharging into the Taunton River has also been provided.

When the new works are put in operation the use of the Taunton River as a source of supply will be discontinued, although water may still be drawn from the filter-basin. It is proposed, however, to retain the pipe connecting with the river for use in cases of emergency.

Chemical Examination of Water from the Filter-Basin of the Taunton Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9952	Jan. 30	V. slight.	V. slight.	0.90	5.80	1.95	.0062	.0212	.0158	.0054	.57	.0120	.0001	.8103	1.7
10057	Feb. 28	V. slight.	V. slight.	0.50	5.00	1.45	.0008	.0096	-	-	.56	.0100	.0001	.4572	1.9
10176	Mar. 28	None.	V. slight.	0.60	3.95	1.20	.0008	.0092	-	-	.46	.0150	.0000	.4708	0.9
10317	Apr. 26	None.	V. slight.	0.35	5.85	-	.0000	.0042	-	-	.56	.0100	.0000	.3248	1.6
10440	May 23	V. slight.	V. slight.	1.90	4.95	-	.0018	.0218	-	-	.45	.0050	.0000	1.2487	0.5
10577	June 29	V. slight.	V. slight.	1.10	5.20	-	.0004	.0150	-	-	.49	.0100	.0000	.7939	1.1
10695	July 25	V. slight.	Slight.	0.60	5.10	-	.0000	.0160	-	-	.62	.0070	.0001	.4662	1.4
10915	Aug. 29	V. slight.	Slight.	1.10	5.60	2.70	.0004	.0190	.0164	.0026	.57	.0150	.0000	.9322	1.2
11066	Sept. 25	Slight.	V. slight.	0.55	6.30	-	.0022	.0140	-	-	.65	.0180	.0000	.4879	1.7
11234	Oct. 23	V. slight.	Slight.	0.60	6.00	-	.0076	.0154	-	-	.66	.0050	.0002	.3914	1.7
11392	Nov. 27	V. slight.	V. slight.	0.63	5.45	-	.0078	.0146	-	-	.68	.0200	.0002	.6751	1.8
11518	Dec. 18	Distinct.	V. slight.	0.95	5.75	-	.0032	.0190	-	-	.61	.0100	.0000	1.0575	1.4
Av.	....	....	....	0.82	5.41	1.82	.0026	.0149	-	-	.57	.0114	.0001	.6763	1.4

Averages of Analyses of Previous Years.

-	1887*	-	-	0.29	5.66	-	.0017	.0092	-	-	.60	.0167	-	-	-
-	1888	-	-	0.47	5.40	-	.0010	.0120	-	-	.53	.0150	.0001	-	-
-	1889	-	-	0.29	5.12	-	.0012	.0073	-	-	.57	.0185	.0001	-	-
-	1890	-	-	0.33	5.91	-	.0012	.0087	-	-	.57	.0227	.0001	-	1.9
-	1891	-	-	0.35	5.25	3.76	.0014	.0073	-	-	.55	.0212	.0000	-	1.7
-	1892	-	-	0.60	5.53	3.88	.0005	.0124	-	-	.58	.0147	.0001	-	1.6
-	1893	-	-	0.82	5.41	1.82	.0026	.0149	-	-	.57	.0114	.0001	.6763	1.4

* June to December.

Note to analyses of 1893; Iron, .0278. Odor, distinctly vegetable and grassy, very rarely unpleasant. — The samples were collected from a faucet at the pumping station while pumping. Water from the Taunton River is admitted directly to the filter-basin whenever the yield of the latter is insufficient for the supply of the city.

TAUNTON.

Microscopical Examination of Water from the Filter-Basin of the Taunton Water Works.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov	Dec.
Day of examination,	31	1	29	27	24	30	26	31	27	24	28	20
Number of sample,	9952	10057	10176	10317	10440	10577	10695	10916	11086	11234	11392	11518
PLANTS.												
Diatomaceæ,	4	6	25	5	2	2	3	1	22	1	13	2
Diatoma,	0	0	2	0	0	0	0	0	0	0	5	0
Fragilaria,	0	0	12	0	0	0	0	0	20	0	0	0
Melosira,	2	0	6	0	0	0	0	0	0	0	7	0
Navicula,	2	2	2	2	0	1	2	0	1	0	pr.	0
Synedra,	pr.	4	3	3	2	1	1	1	1	1	1	2
Cyanophyceæ, Oscillaria,	0	0	0	2	pr.	0	2	0	2	6	2	0
Fungi, Crenothrix,	pr.	192	1	0	8	10	60	48	12	26	pr.	7
ANIMALS.												
Infusoria,	1	2	6	0	0	0	0	1	0	0	pr.	0
Dinobryon cases,	0	pr.	2	0	0	0	0	0	0	0	0	0
Peridinium,	1	2	4	0	0	0	0	1	0	0	pr.	0
Miscellaneous, Zoöglœa,	5	72	32	12	0	0	6	28	5	0	2	8
TOTAL,	10	272	64	19	10	12	71	78	41	33	17	17

Chemical Examination of Water from the Taunton River at Taunton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
9951	Jan. 30	Slight.	Slight.	1.20	6.05	2.20	.0064	.0244	.0208	.0036	.62	.0090	.0001	1.0249	1.5
10056	Feb. 28	Slight.	Slight.	1.10	4.95	1.95	.0010	.0184	.0142	.0042	.57	.0090	.0001	.9504	1.1
10175	Mar. 28	Slight.	Slight.	1.10	3.55	1.80	.0006	.0172	.0136	.0036	.47	.0100	.0000	.8176	0.5
10316	Apr. 26	V. slight.	Slight.	1.30	4.55	2.15	.0000	.0212	.0190	.0022	.46	.0050	.0001	1.2045	0.6
10439	May 23	Slight.	Cons.	2.50	4.95	2.45	.0022	.0290	.0264	.0026	.38	.0050	.0000	1.6087	0.5
10576	June 29	None.	Slight.	1.80	5.20	2.95	.0006	.0284	.0246	.0038	.49	.0070	.0001	1.2403	0.9
10694	July 25	V. slight.	Slight.	1.20	5.05	2.00	.0018	.0268	.0236	.0032	.61	.0070	.0001	.7326	0.8
10914	Aug. 29	V. slight.	Slight.	2.20	6.65	3.55	.0018	.0348	.0318	.0030	.52	.0080	.0001	1.7617	1.0
11087	Sept. 25	Slight.	Slight.	0.90	5.15	1.70	.0116	.0200	.0176	.0024	.67	.0120	.0002	.6478	1.3
11233	Oct. 23	Slight.	Slight.	0.90	6.70	2.55	.0212	.0238	.0160	.0078	.70	.0030	.0005	.5320	1.3
11391	Nov. 27	Slight.	Slight.	1.00	5.55	2.05	.0008	.0220	.0202	.0018	.72	.0100	.0004	1.1266	1.6
11517	Dec. 18	Distinct.	Cons.	1.35	5.60	2.35	.0030	.0294	.0262	.0032	.54	.0080	.0001	1.3365	1.1
Av.	....	....	....	1.38	5.33	2.31	.0043	.0246	.0212	.0034	.56	.0078	.0002	1.0820	1.1

TAUNTON.

Chemical Examination of Water from the Taunton River at Taunton—Concluded.

Averages of Analyses of Previous Years.

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
-	1887*	-	-	1.29	5.84	2.09	.0030	.0285	-	-	.59	.0097	-	-	-
-	1888	-	-	1.51	5.25	2.28	.0015	.0294	-	-	.44	.0086	.0001	-	-
-	1889	-	-	1.67	4.50	2.17	.0015	.0304	.0270	.0034	.45	.0085	.0001	-	-
-	1890	-	-	1.31	5.36	2.27	.0016	.0254	.0225	.0029	.48	.0118	.0001	-	1.3
-	1891	-	-	1.12	4.77	1.98	.0006	.0220	.0197	.0023	.47	.0095	.0001	-	1.0
-	1892	-	-	1.08	5.27	2.20	.0012	.0225	.0198	.0027	.54	.0093	.0001	-	1.1
-	1893	-	-	1.38	5.33	2.31	.0043	.0246	.0212	.0034	.56	.0078	.0002	1.0820	1.1

* June to December.

Note to analyses of 1893; Iron, .0302. Odor, decidedly vegetable and sweetish, rarely mouldy or unpleasant. —— The samples were collected from the river opposite the filter-basin of the Taunton Water Works.

Microscopical Examination of Water from the Taunton River at Taunton.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Mar.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	31	1	29	27	24	30	26	31	27	24	28	20
Number of sample,	9951	10056	10175	10316	10439	10576	10694	10914	11087	11283	11391	11517
PLANTS.												
Diatomaceæ,	2	11	21	145	7	6	6	7	2	3	13	6
Fragilaria,	0	4	6	0	0	0	0	0	0	0	0	0
Melosira,	1	1	1	4	3	0	0	0	0	0	1	0
Meridion,	0	1	8	2	1	0	0	0	0	0	0	0
Navicula,	0	4	pr.	1	0	0	1	2	1	1	0	2
Synedra,	1	1	6	134	1	3	4	5	0	2	3	4
Tabellaria,	pr.	pr.	0	4	2	3	1	0	1	0	9	0
Fungi, Crenothrix,	4	1	3	32	64	5	5	80	2	2	4	9
ANIMALS.												
Infusoria,	1	4	17	0	0	0	0	1	0	1	2	0
Dinobryon,	0	3	11	0	0	0	0	0	0	0	0	0
Dinobryon cases,	0	pr.	2	0	0	0	0	0	0	0	2	0
Peridinium,	1	1	4	0	0	0	0	1	0	1	pr.	0
Miscellaneous, Zoöglœa,	15	5	42	108	30	24	13	88	24	10	2	56
Total,	22	21	83	285	101	35	24	176	23	16	21	71

page 39 of this volume, and on page 46 of the annual report of the Board for 1892.

Analyses of samples of water from these sources are given in the following tables.

Chemical Examination of Water from Cold Spring and Seagrave Brooks, Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10150	Mar. 25	None.	V. slight.	0.60	2.40	1.16	.0002	.0070	.0050	[illegible]	.14	.0000	.0000	.4590	0.6
10160	Mar. 25	None.	Slight.	0.68	2.46	0.76	.0000	.0084	[illegible]	.0018	.16	.0000	.0000	.4891	0.1

Iron in the first sample, .0000; in the last, .0060. Odor of the first sample, distinctly vegetable; of the last, faintly vegetable, becoming stronger on heating.—The first sample was collected from Cold Spring Brook at the point where it is crossed by the Old Douglas road, between Uxbridge and East Douglas; the last sample, from Seagrave Brook at the point where it was proposed to divert the water, a little less than a mile above its junction with Emerson Brook.

Microscopical Examination.

No. 10150. Diatomaceæ, *Meridion*, 2. Miscellaneous, *Zoöglœa*, 26. Total, 28.

No. 10160. Diatomaceæ, *Diatoma*, 3; *Fragilaria*, 4; *Gomphonema*, 2; *Meridion*, 26; *Navicula*, 1; *Synedra*, 2. Miscellaneous, *Zoöglœa*, 20. Total, 58.

Chemical Examination of Water from Mendon Pond, Mendon.

[Parts per 100,000.]

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

Iron, .0048. Odor, generally faintly vegetable or none, rarely mouldy or disagreeable; on heating, the odor is somewhat stronger and frequently mouldy.—The samples were collected from the pond within three feet of the surface, with the exception of Nos. 10665 and 10930, which were collected at depths of fourteen and one-half and twelve and one-half feet respectively beneath the surface.

Microscopical Examination of Water from Mendon Pond, Mendon.

[Number of organisms per cubic centimeter.]

	1892.										
	June.	June.	July.	July.	Aug.	Aug.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	1	30	16	16	31	31	31	28	26	28	25
Number of sample,	10455	10575	10664	10666	10928	10929	10930	11095	11261	11404	11539
PLANTS.											
Diatomaceæ,	7	10	8	6	1	15	26	71	420	1,990	1,697
Asterionella,	0	0	0	0	0	12	15	56	27	370	47
Synedra,	4	10	0	0	pr.	0	0	1	12	20	10
Tabellaria,	3	0	8	6	1	3	11	14	380	1,600	1,640
Cyanophyceæ, Merismopedia,	0	0	0	0	6	4	10	0	0	0	0
Algæ,	63	11	0	6	22	26	21	194	15	10	0
Botryococcus,	0	0	0	0	12	5	10	0	0	0	0
Chlorococcus,	3	0	0	0	0	0	0	0	4	0	0
Protococcus,	60	9	0	0	0	5	0	0	10	9	0
Raphidium,	11	2	0	6	9	14	11	192	0	0	0
Staurastrum,	pr.	pr.	0	[illegible]	1	2	pr.	2	1	1	0
ANIMALS.											
Rhizopoda, Actinophrys,	[illegible]	0	0	0	12	4	2	0	3	1	0
Infusoria,	0	36	40	190	pr.	9	3	3	0	[illegible]	0
Dinobryon cases,	0	0	0	184	0	6	1	0	0	[illegible]	0
Monas,	pr.	0	0	0	0	pr.	0	1	0	0	0
Peridinium,	0	36	40	6	pr.	3	2	2	0	0	0
Vermes, Polyarthra,	0	0	0	0	0	0	pr.	1	0	0	0
Crustacea, Cyclops,	0	0	0	0	0	.03	.04	0	0	0	[illegible]
Miscellaneous,	3	16	0	20	30	32	44	32	1	5	0
Acarina,	0	0	0	0	0	.06	.08	0	0	0	0
Zoöglœa,	3	16	0	20	30	32	44	32	1	5	0
TOTAL,	105	73	48	224	71	90	106	301	439	2,016	1,697

UXBRIDGE.

Chemical Examination of Water from Meadow Brook, Mendon.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
10161	1893. Mar. 25	None.	V. slight.	0.38	2.40	0.80	.0008	.0102	.0074	.0028	.09	.0030	.0001	.3650	0.5

Iron, .0000. Odor, decidedly vegetable and grassy.——The sample was collected from the brook, which is the outlet of Mendon Pond, at Robinson's saw mill, about a mile below the pond.

Microscopical Examination.

Miscellaneous, *Zoöglœa*, 20.

Chemical Examination of Water from Mumford River, at Uxbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
10716	1893. Aug. 2	Slight.	Slight.	0.45	2.75	1.00	.0000	.0172	.0148	.0024	.24	.0050	.0001	.2590	1.1

Iron, .0350. Odor, distinctly mouldy and disagreeable, becoming stronger on heating.——The sample was collected from Capron's Pond, a mill pond on the Mumford River, in the village of Uxbridge.

Microscopical Examination.

Diatomaceæ, *Epithemia*, 1; *Stauroneis*, 1; *Synedra*, 28; *Tabellaria*, 8. Cyanophyceæ, *Merismopedia*, 4. Algæ, *Cosmarium*, 1; *Raphidium*, 4. Fungi, *Crenothrix*, 8. Infusoria, *Trachelomonas*, 1. Miscellaneous, *Zoöglœa*, 156. Total, 212.

Water Supply of Wakefield and Stoneham — Wakefield Water Company.

The advice of the State Board of Health to the Wakefield Water Company, with reference to obtaining an additional water supply from the valley of Saugus River and its tributaries, within the limits of the town of Wakefield, may be found on page 58 of this volume.

The advice of the Board to the city of Lynn with reference to taking an additional supply of water from the valley of the Saugus River and its tributaries, may be found on page 25.

Chemical Examination of Water from Crystal Lake, Wakefield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
10007	Feb. 13	Slight.	V. slight.	0.03	2.30	0.75	.0124	.0126	.0110	.0016	.39	.0200	.0001	.1768	0.9
10250	Apr. 12	Distinct.	Cons., white.	0.08	4.25	1.00	.0014	.0138	.0122	.0016	.52	.0300	.0001	.2372	1.7
10518	June 14	Slight.	Slight.	0.20	3.85	1.65	.0018	.0206	.0172	.0034	.64	.0050	.0000	.3182	1.5
10864	Aug 18	Distinct.	Slight.	0.18	4.35	1.70	.0000	.0192	.0172	.0020	.60	.0000	.0001	.3120	1.6
11199	Oct. 16	Slight.	Slight.	0.18	4.05	1.20	.0004	.0176	.0154	.0022	.64	.0030	.0000	.3078	1.7
11479	Dec. 12	Slight.	Slight.	0.15	3.90	1.10	.0000	.0152	[illegible]	.0044	.61	.0080	.0000	.2416	1.6
11507	Dec. 16	V. slight.	Slight.	0.15	4.20	1.60	.0014	.0186	[illegible]	.0014	.63	.0050	.0000	.2163	1.7
Av.*	....	....	....	0.14	3.81	1.27	.0028	.0164	.0141	.0023	.57	.0108	.0001	.2636	1.5

Averages of Analyses of Previous Years.

-	1887†	-	-	0.17	3.73	0.91	.0006	.0174	-	-	.51	.0043	-	-	-
-	1888‡	-	-	0.13	3.59	0.92	.0009	.0167	-	-	.48	.0080	.0001	-	-
-	1889§	-	-	0.10	3.60	0.87	.0009	.0141	.0119	.0022	.49	.0163	.0002	-	-
-	[illegible]	-	-	0.25	4.22	1.35	.0001	.0371	.0190	.0181	.46	.0090	.0001	-	1.5
-	1891¶	-	-	0.06	4.17	1.60	.0005	.0160	.0129	.0031	.47	.0145	.0001	-	1.6
-	1893	-	-	0.14	3.81	1.27	.0028	.0164	.0141	.0023	.57	.0108	.0001	.2636	1.5

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December. ‡ January to October. § January, March and June.

‖ Three in October. ¶ May and November.

NOTE to analyses of 1893; Iron, .0109. Odor, generally faintly vegetable, rarely none; in June, disagreeable; on heating, the odor is generally considerably stronger, and in the April sample was oily

WAKEFIELD AND STONEHAM.

Microscopical Examination of Water from Crystal Lake, Wakefield.

[Number of organisms per cubic centimeter.]

	1893.						
	Feb.	April.	June.	Aug.	Oct.	Dec.	Dec.
Day of examination,	15	14	15	19	17	13	19
Number of sample,	10007	10250	10518	10864	11199	11479	11507
PLANTS.							
Diatomaceæ,	**0**	**7**	**1,199**	**18**	**514**	**275**	**132**
Asterionella,	0	1	0	0	64	68	53
Cyclotella,	0	1	44	1	36	28	47
Diatoma,	0	0	0	0	12	0	0
Fragilaria,	0	0	34	0	30	25	0
Melosira,	0	0	1	3	30	0	0
Synedra,	0	3	1,120	0	0	2	0
Tabellaria,	0	2	0	14	342	152	32
Cyanophyceæ,	**0**	**0**	**14**	**104**	**11**	**0**	**0**
Anabæna,	0	0	14	28	0	0	0
Anabæna spores,	0	0	0	20	0	0	0
Chroöcoccus,	0	0	0	0	4	0	0
Clathrocystis,	0	0	0	28	0	0	0
Microcystis,	0	0	0	28	7	0	0
Algæ,	**0**	**0**	**82**	**124**	**0**	**0**	**0**
Pandorina,	0	0	4	0	0	0	0
Protococcus,	0	0	54	124	0	0	0
Scenedesmus,	0	0	24	0	0	0	0
Fungi, Crenothrix,	**0**	**0**	**0**	**0**	**5**	**1**	**0**
ANIMALS.							
Rhizopoda, Arcella,	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Infusoria,	**0**	**7**	**2**	**8**	**33**	**0**	**0**
Dinobryon,	0	0	0	4	5	0	0
Dinobryon cases,	0	0	0	0	8	0	0
Euglena,	0	0	0	1	0	0	0
Peridinium,	0	7	pr.	1	0	0	0
Synura,	0	0	2	0	0	0	0
Trachelomonas,	0	0	0	2	20	0	0
Miscellaneous, Zoöglœa,	**52**	**20**	**26**	**28**	**16**	**3**	**0**
TOTAL,	52	36	1,323	282	579	279	132

WALPOLE.

The advice of the State Board of Health to the town of Walpole with reference to taking a water supply from the ground near the Neponset River, or tributaries thereof, within the limits of the town, may be found on page 60 of this volume. Analyses of samples of water collected from tubular test wells near the Neponset River are given in the following table.

Chemical Examination of Water from Tubular Test Wells near the Neponset River, in Walpole.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10270	Apr. 19	None.	None.	0.02	4.00	.0002	.0004	.33	.0100	.0000	.0000	0.8	.0020
10271	Apr. 19	None.	Cons., sand.	0.00	5.70	.0002	.0004	.36	[redacted]	.0000	.0146	1.1	.0110

Odor, none.—The samples were collected from tubular test wells on the easterly side of the Neponset River about one mile south of the village of Walpole. The first sample was collected from Well No. 1, twenty feet in depth, located about seventy-five feet from the Neponset River and about seven hundred and fifty feet down stream (northerly) from the mouth of Low Brook; the last sample, from Well No. 2, thirty feet in depth, located about ninety feet from the Neponset River and about fifteen feet northerly from Low Brook.

Microscopical Examination.

No. 10270. No organisms.
No. 10271. Diatomaceæ, *Synedra*, 1.

Water Supply of Waltham.

Much trouble has been caused in recent years by the rapid growth of certain low forms of vegetation in the filter-basin and well of the Waltham water works, and with a view to preventing this growth the filter-basin and well were covered in the autumn of 1893. The work was completed before the November and December samples were collected, and the improvement in the quality of the water may be seen by examining the tables of analyses which follow. Reference is also made to the character of the well water in a reply of the State Board of Health to the Water Commissioners of Waltham, which can be found on page 61 of this volume. The distributing reservoir has not been covered, so that the quality of the portion of the water supply of the city which passes through it is affected as in the past by the abundant growths of microscopic organisms.

The filter-basin before being covered had the shape of a rectangle with one corner cut off, and an area of about ten thousand square feet. The well, which is located in the centre of the filter-basin, is forty feet in diameter and is covered with a dome made of flat tiles laid in Portland cement. The portion of the filter-basin outside of the well is covered with a series of brick arches. The shape and size of the filter-basin were not materially changed.

WALTHAM.

Chemical Examination of Water from the Well and Filter-Basin of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9863	Jan. 10	None.	None.	.00	6.95	.0048	.0082	.48	.0180	.0000	.0720	3.5	.0000
9930	Jan. 24	Slight.	Cons.	.02	6.85	.0072	.0098	.50	.0220	.0001	.0657	3.4	.0160
10006	Feb. 13	None.	None.	.02	6.30	.0036	.0032	.51	.0200	.0000	.0620	3.6	.0000
10046	Feb. 28	None.	None.	.02	6.95	.0024	.0026	.48	.0100	.0000	.0763	3.5	.0000
10109	Mar. 13	None.	None.	.00	6.25	.0020	.0034	.57	.0180	.0003	.0688	3.8	.0000
10171	Mar. 27	None.	V. slight.	.02	6.65	.0026	.0018	.46	.0180	.0001	.0657	3.2	.0000
10236	Apr. 11	None.	V. slight.	.00	6.45	.0030	.0026	.41	.0250	.0000	.0676	3.0	.0030
10323	Apr. 26	None.	None.	.00	6.65	.0014	.0012	.45	.0180	.0000	.0620	3.1	.0000
10391	May 15	None.	None.	.00	6.90	.0038	.0016	.47	.0180	.0000	.0474	3.0	.0000
10514	June 13	V. slight.	None.	.00	7.20	.0034	.0018	.50	.0300	.0000	.0368	3.1	.0000
10652	July 12	None.	None.	.00	6.80	.0048	.0022	.45	.0120	.0000	.0365	3.5	.0025
10805	Aug. 15	None.	None.	.00	6.80	.0022	.0010	.44	.0200	.0000	.0592	3.2	.0000
11020	Sept. 13	None.	None.	.00	6.75	.0032	.0024	.46	.0200	.0000	.0624	3.4	.0000
11161	Oct. 10	None.	None.	.03	7.45	.0060	.0022	.48	.0070	.0000	.0462	3.8	.0050
11331	Nov. 14	None.	V. slight.	.00	7.05	.0030	.0010	.48	.0180	.0000	.1369	3.4	.0050
11474	Dec. 12	None.	None.	.00	6.85	.0030	.0008	.48	.0150	.0000	.0664	3.5	.0025
Av.*	....	....	....	.01	6.86	.0036	.0022	.47	.0179	.0000	.0643	3.4	.0020

Averages of Analyses of Previous Years.

-	1887†	-	-	.00	6.71	.0007	.0038	.47	.0250	-	-	-	-
-	1888	-	-	.00	6.70	.0009	.0054	.46	.0273	.0003	-	-	-
-	1889‡	-	-	.00	6.43	.0006	.0034	.48	.0378	.0002	-	-	-
-	1890§	-	-	.00	-	.0000	.0012	.47	.0380	.0002	-	-	-
-	1892	-	-	.00	6.81	.0033	.0027	.45	.0162	.0000	-	3.4	-
-	1893	-	-	.01	6.86	.0036	.0022	.47	.0179	.0000	.0643	3.4	.0020

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December. ‡ January to May. § July.

NOTE to analyses of 1893; Odor of No 9930 none, becoming distinctly aromatic after standing one day; of No. 10160, distinctly aromatic; of No. 10171, very faintly vegetable; of Nos. 10323 to 10652, inclusive, unpleasant or disagreeable; of all other samples, none. The odor in nearly every case disappeared on heating.——The samples were collected either from a faucet at the pumping station while pumping, or from the filter-basin. The November and December samples were collected after the covering of the filter-basin had been completed.

WALTHAM.

Microscopical Examination of Water from the Well and Filter-Basin of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1893.															
	Jan.	Jan.	Feb.	Feb.	Mar.	Mar.	Apr.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination, . .	11	26	14	28	14	28	13	27	16	14	15	16	14	10	14	13
Number of sample, . .	9863	9930	10006	10046	10109	10171	10236	10323	10391	10514	10652	10805	11020	11161	11331	11474
PLANTS.																
Diatomaceæ, .	25	2,928	6	16	21	1	21	23	15	11	0	0	4	2	0	0
Asterionella,	20	2,506	0	0	0	0	0	5	4	0	0	0	0	0	0	0
Fragilaria, .	0	34	0	0	3	pr.	7	0	0	0	0	0	0	0	0	0
Melosira, .	0	0	0	8	7	0	7	2	9	9	0	0	3	2	0	0
Meridion, .	2	0	0	pr.	4	1	1	0	0	0	0	0	0	0	0	0
Navicula, .	1	0	1	2	1	0	2	0	0	1	0	0	0	0	0	0
Synedra, .	1	240	3	6	6	0	4	16	2	1	0	0	1	0	0	0
Tabellaria, .	1	148	2	pr.	pr.	pr.	pr.	0	0	0	0	0	0	0	0	0
Cyanophyceæ, Chroococcus, .	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algæ, . .	1	pr.	4	pr.	4	pr.	1	0	22	0	0	1	0	0	0	0
Pandorina, .	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0
Scenedesmus,	1	pr.	4	pr.	4	pr.	1	0	1	0	0	1	0	0	0	0
ANIMALS.																
Infusoria, .	0	0	0	0	1	0	0	0	234	0	1	0	0	0	0	0
Dinobryon, .	0	0	0	0	0	0	0	0	54	0	0	0	0	0	0	0
Dinobryon cases, . .	0	0	0	0	0	0	0	0	180	0	0	0	0	0	0	0
Peridinium, .	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Miscellaneous, Zoöglœa, .	0	28	0	0	1	12	0	0	6	1	0	1	0	13	0	0
TOTAL, .	26	2,964	10	16	27	13	22	23	277	12	1	2	4	15	0	0

WALTHAM.

Chemical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9862	Jan. 10	Distinct.	Cons.	.02	6.70	.0000	.0082	.48	.0100	.0001	.0800	3.5	.0000
9929	Jan. 24	None.	None.	.00	7.05	.0054	.0024	.52	.0180	.0001	.0474	3.5	.0020
10005	Feb. 13	None.	Cons., dark.	.00	6.45	.0026	.0056	.51	.0250	.0000	.0803	3.2	.0000
10047	Feb. 28	None.	Cons., dark.	.03	6.55	.0018	.0032	.49	.0070	.0000	.0936	3.1	.0025
10110	Mar. 13	Slight.	Cons.	.03	6.60	.0000	.0046	.54	.0200	.0000	.1021	3.2	.0020
10172	Mar. 27	Decided.	Cons., dark,	.03	6.90	.0000	.0092	.41	.0100	.0001	.1168	2.9	.0050
10237	Apr. 11	Distinct.	Cons., white.	.04	6.70	.0000	.0124	.44	.0220	.0000	.1022	2.7	.0025
10322	Apr. 26	Slight.	Cons.	.02	5.50	.0002	.0106	.43	.0070	.0000	.1131	2.9	.0000
10390	May 15	Distinct.	Cons.	.05	6.65	.0000	.0136	.42	.0150	.0000	.1277	2.6	.0000
10515	June 13	Slight.	Slight.	.08	7.20	.0000	.0098	.51	.0160	.0002	.1072	3.0	.0000
10651	July 12	Distinct, green.	Slight, green.	.05	6.70	.0012	.0078	.46	.0150	.0000	.0730	3.2	.0070
10806	Aug. 15	Distinct, green.	Slight, green.	.01	6.60	.0000	.0044	.44	.0070	.0001	.0671	3.0	.0025
11021	Sept. 13	Slight.	Slight.	.03	6.75	.0000	.0066	.48	.0180	.0001	.0936	3.4	.0000
11160	Oct. 10	Slight.	Cons., white.	.06	6.85	.0000	.0078	.50	.0000	.0001	.1001	3.5	.0020
11330	Nov. 14	Slight.	Cons., white.	.03	6.90	.0000	.0064	.45	.0110	.0001	.1909	3.1	.0020
11475	Dec. 12	Distinct, green.	Slight.	.03	6.70	.0000	.0048	.48	.0120	.0001	.1120	3.2	.0020
Av.*	....	....	....	.04	6.72	.0006	.0074	.47	.0127	.0001	.1033	3.1	.0019

Averages of Analyses of Previous Years.

-	1887†	-	-	.00	6.66	.0007	.0061	.46	.0197	-	-	-	-
-	1888	-	-	.00	6.45	.0003	.0075	.46	.0248	.0003	-	-	-
-	1889‡	-	-	.00	6.21	.0003	.0078	.47	.0280	.0003	-	-	-
-	1890§	-	-	.00	-	.0000	.0124	.47	.0280	.0001	-	-	-
-	1891‖	-	-	.00	6.25	.0000	.0041	.40	.0200	.0000	-	3.0	-
-	1892	-	-	.01	6.28	.0006	.0082	.44	.0119	.0001	-	3.0	-
-	1893	-	-	.04	6.72	.0006	.0074	.47	.0127	.0001	.1033	3.1	.0019

* Where more than one sample was collected in a month the mean analysis for that month has been used in making the average.

† June to December. ‡ January to May. § February. ‖ May.

NOTE to analyses of 1893; Odor, generally faintly aromatic or unpleasant or none; on heating, the odor is stronger and occasionally disagreeable or fishy. —— The samples were collected from the reservoir at the gate-house, with the exception of the last two, which were collected from the reservoir at the side opposite the gate-house.

WALTHAM.

Microscopical Examination of Water from the Distributing Reservoir of the Waltham Water Works.

[Number of organisms per cubic centimeter.]

	1893.							
	Jan.	Jan.	Feb.	Feb.	Mar.	Mar.	Apr.	Apr.
Day of examination,	11	26	14	28	14	28	13	27
Number of sample,	9862	9929	10005	10047	10110	10172	10237	10322
PLANTS.								
Diatomaceæ,	3,364	pr.	299	194	4,267	5,996	18,944	13,700
Asterionella,	2,920	0	246	168	3,916	5,360	9,544	5,560
Cyclotella,	52	0	3	7	0	0	0	0
Fragilaria,	0	0	15	0	0	0	0	0
Melosira,	0	0	2	0	10	0	0	0
Synedra,	88	pr.	11	18	336	636	9,400	8,140
Tabellaria,	304	0	22	1	5	0	0	0
Algæ,	149	pr.	7	7	7	0	9	0
Chlorococcus,	0	0	0	2	0	0	1	0
Protococcus,	148	0	0	0	2	0	0	0
Raphidium,	0	0	0	0	0	0	0	0
Scenedesmus,	1	pr.	7	5	5	0	8	0
Fungi, Crenothrix,	0	0	23	12	0	0	0	0
ANIMALS.								
Rhizopoda, Actinophrys,	0	0	0	0	0	0	0	0
Infusoria,	5	0	pr.	0	pr.	0	1	48
Dinobryon,	5	0	0	0	0	0	0	47
Dinobryon cases,	0	0	0	0	pr.	0	0	0
Encysted protozoa,	0	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0
Peridinium,	0	0	pr.	0	pr.	0	1	1
Uvella,	0	0	0	0	0	0	0	0
Vermes, Rotatorian ova,	0	0	0	0	pr.	0	0	1
Miscellaneous, Zoöglœa,	0	0	12	7	0	44	0	3
TOTAL,	3,518	pr.	341	220	4,274	6,040	18,954	13,752

WATER SUPPLY OF WARE.

The works for collecting water for this town were enlarged in the latter part of 1893 by sinking twelve tubular wells in the valley of Muddy Brook, about 500 feet north of the large well, which was previously the only source of supply for the town; and by constructing a well nine feet in diameter and six feet in depth at the

WALT

Microscopical Examination of Water from the Distributing Reservoir of Waltham Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1893.							
	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	
Day of examination,	16	14	15	16	14	10	14	
Number of sample,	10390	10515	10651	10806	11021	11160	11330	
PLANTS.								
Diatomaceæ,	**13,460**	**231**	**1,100**	**5,400**	**1,140**	**888**	**14,888**	
Asterionella,	980	212	920	4,840	700	888	14,800	
Cyclotella,	0	6	pr.	0	0	0	0	
Fragilaria,	0	0	0	0	0	0	0	
Melosira,	0	2	0	0	0	0	12	
Synedra,	12,480	8	180	560	440	0	0	
Tabellaria,	0	3	0	0	0	0	26	
Algæ,	**2**	**1**	**1**	**2**	**180**	**4**	**22**	
Chlorococcus,	0	0	0	0	0	4	2	
Protococcus,	0	0	0	0	0	0	20	
Raphidium,	0	0	0	0	180	0	0	
Scenedesmus,	2	1	1	2	0	0	0	
Fungi, Crenothrix,	**0**	**1**	**0**	**0**	**0**	**2**	**0**	
ANIMALS.								
Rhizopoda, Actinophrys,	**3**	**0**	**0**	**0**	**0**	**0**	**0**	
Infusoria,	**7**	**333**	**4**	**32**	**23**	**181**	**32**	
Dinobryon,	0	196	0	0	0	164	30	1
Dinobryon cases,	0	136	2	0	18	9	0	2
Encysted protozoa,	7	0	0	0	0	0	0	
Monas,	0	1	0	0	1	0	2	
Peridinium,	0	0	2	32	4	0	0	
Uvella,	0	0	0	0	0	8	0	
Vermes, Rotatorian ova,	**0**	**0**	**0**	**2**	**0**	**0**	**0**	
Miscellaneous, Zoöglœa,	**0**	**5**	**70**	**28**	**0**	**32**	**4**	
TOTAL,	13,472	571	1,175	5,464	1,343	1,107	14,896	4,81

site of a large spring located near the tubular wells. The tubular wells are located within an area approximately 150 feet in length and somewhat less than 100 feet in width. The depth of the wells varies from twenty-eight to thirty-nine feet and averages thirty-four feet. Water from the wells and spring flows by gravity through a twelve-inch pipe to the main well.

WARE.

Chemical Examination of Water from the Well of the Ware Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1892.												
9998	Feb. 13	None.	None.	0.0	9.55	.0004	.0022	.96	.3500	.0000	.0657	3.5	.000

Water Supply of Watertown and Belmont — Watertown Water Supply Company.

The Watertown Water Supply Company made extended investigations in 1893 with reference to obtaining an additional supply of water from the ground in the vicinity of its pumping station and examined other sources. The company also made an application to the State Board of Health for its advice relative to the improvement of its supply, and many of the analyses given in the following tables were made during the investigations of the Board, but at the end of the year the matter was still under consideration.

The investigations showed that the water collected by the original filter-gallery and by a system of tubular wells northwesterly from the pumping station was nearly the same in character as during the earlier years of the operation of the works, but water collected from the ground in an easterly direction from the pumping station has to a greater or less degree the usual characteristics of a water containing iron. The most successful results were obtained from some six-inch wells located about 950 feet southeast of the pumping station, and about forty feet from the river. A temporary pump was connected with these wells in the summer of 1893, and during the summer and autumn a material addition to the water supply was obtained from this source. The last three analyses in the table on page 314 are of samples of water from these wells. It is probable that most of the water which they supplied came by filtration from the river, and although it contained iron and manganese and did not show the high degree of chemical purification which water attains when it filters a sufficient distance through the ground under favorable circumstances, it was rendered very nearly pure, bacterially, by the filtration.

The table on page 315 contains the analyses of water from two deep tubular wells, one located near the pumping station, and the other in the centre of the main village of Watertown. Neither of these deep wells furnished any large quantity of water nor was the quality of the water satisfactory, and no part of the water supply of the town is now taken from them.

Chemical Examination of Water from a Faucet in the Pumping Station of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.
	1893.												
9990	Feb. 6	V. slight.	V. slight.	.02	7.70	.0012	.0062	.67	.0700	[redacted]	[redacted]	3.5	.0130
10105	Mar. 8	None.	None.	.05	6.05	.0006	.0010	.66	.0800	[redacted]	.0360	3.8	.0020
10245	Apr. 11	V. slight.	V. slight.	.05	6.45	.0016	.0126	.49	.0650	.0000	.1241	2.5	.0045
10417	May 17	None.	None.	.02	6.05	[redacted]	.0054	.65	.0950	.0000	.0730	2.7	.0060
10602	June 8	None.	None.	.00	7.75	.0000	.0030	.67	.0900	.0000	.0402	3.6	.0050
10620	July 7	Slight, milky.	Slight, rusty.	.25	8.60	.0066	.0068	.60	.0400	.0001	.1241	3.4	.0030
10741	Aug. 6	V. slight.	V. slight.	.20	7.70	.0098	.0046	.64	.0250	.0001	.1184	4.3	.0240
11040	Sept. 16	Distinct, milky	Slight, rusty.	.65	9.00	.0186	.0068	.72	.0100	.0002	.2418	3.7	.1050
11155	Oct. 9	Distinct, milky.	Slight, fibrous.	.60	8.70	.0160	.0074	.76	.0050	.0000	.2040	3.6	.0720
11307	Nov. 8	Distinct.	Slight.	.30	7.80	.0076	.0054	.76	.0300	.0002	.1680	3.5	.0435
11466	Dec. 6	None.	V. slight.	.10	7.60	.0056	.0035	.72	.0230	.0001	.1560	3.6	.0300
Av.	....	....	....	.19	7.65	.0063	.0061	[redacted]	.0489	.0001	[redacted]	3.5	.0315

Averages of Analyses of Previous Years.

-	1887*	-	-	.00	7.09	.0005	.0034	.65	.0300	-	-	-	-
-	[redacted]	-	-	.00	7.22	[redacted]	.0040	.63	[redacted]	[redacted]	-	-	-
-	1889†	-	-	.00	6.45	.0000	.0027	.64	.0642	.0000	-	-	-
-	1890‡	-	-	.00	7.40	.0014	.0042	.69	[redacted]	.0000	-	3.9	-
-	1892§	-	-	.07	7.90	.0041	.0046	.66	.0370	[redacted]	-	4.0	.0306
-	1893	-	-	.19	[redacted]	.0063	.0061	.68	.0489	.0001	.1275	3.5	.0315

* June to December. † January to May. ‡ August. § September to December.

NOTE to analyses of 1893; Odor, generally none, occasionally mouldy and unpleasant.—The samples were collected from a faucet at the pumping station while pumping.

In the above table the samples with the higher amounts of iron became turbid and colored by the precipitation of the iron by oxidation on exposure to the air.

WATERTOWN AND BEL

Microscopical Examination of Water from a Faucet in the Pumping Statio[n] Watertown Water Supply Company.

[Number of organisms per cubic centimeter.]

	1893.									
	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	No[v]
Day of examination, ...	11	10	13	19	9	11	8	19	10	1
Number of sample, ...	9990	10105	10245	10417	10502	10620	10741	11040	11155	1130
PLANTS.										
Diatomaceæ, ...	0	0	1	4	0	0	0	5	0	28
Asterionella, ...	0	0	0	4	0	0	0	4	0	0
Synedra, ...	0	0	1	pr.	0	0	0	1	0	20
Tabellaria, ...	0	0	0	0	0	0	0	0	0	8
Cyanophyceæ, . . .	0	0	0	0	6	0	16	0	0	0
Anabæna, ...	0	0	0	0	6	0	0	0	0	0
Oscillaria, ...	0	0	0	0	0	0	16	0	0	0
Fungi, Crenothrix, . .	12	0	pr.	0	0	680	64	520	61	64
Miscellaneous, Zoöglœa, . .	28	0	0	0	0	76	28	240	72	96
TOTAL, ...	40	0	1	4	6	756	108	765	133	188

Chemical Examination of Water from a Faucet in Watertown, supplied f[rom] the Works of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.											
9913	Jan. 23	None.	None.	0.02	10.20	.0000	.0030	.68	.0900	.0001	.0693	4.7
10040	Feb. 20	None.	V. slight.	0.08	6.80	.0000	.0110	.52	.0800	.0001	.2197	3.4
10142	Mar. 20	Distinct, milky.	V. slight.	0.10	6.75	.0000	.0046	.51	.0550	.0000	.1008	2.9
10260	Apr. 18	None.	None.	0.03	6.95	.0000	.0014	.54	.0600	.0000	.1095	3.0
10409	May 17	None.	None.	0.05	7.15	.0010	.0058	.55	.0450	.0002	.0657	3.0
10513	June 13	None.	None.	0.05	8.45	.0000	.0082	.57	.0120	.0001	.0703	3.4
10663	July 13	V. slight.	None.	0.05	8.30	.0004	.0042	.59	.0500	.0000	.1022	3.8
10804	Aug. 15	Slight.	V. slight.	0.15	8.00	.0000	.0044	.66	.0110	.0000	.1280	3.9
11035	Sept. 15	Slight, milky.	V. slight.	0.20	8.70	.0118	.0066	.69	.0090	.0005	.1794	3.9
11219	Oct. 17	V. slight, milky.	None.	0.15	8.70	.0002	.0062	.68	.0300	.0000	.1863	4.2
11365	Nov. 21	V. slight, milky.	None.	0.10	8.30	.0010	.0044	.63	.0270	.0000	.2100	4.3
11534	Dec. 19	V. slight, milky.	None.	0.05	8.40	.0000	.0026	.66	.0420	.0000	.1458	4.2
Av..	....	....	....	0.09	8.06	.0012	.0052	.61	.0426	.0001	.1322	3.7

Odor of the first sample, none, becoming distinctly unpleasant on heating; of the third sample, [dis]tinctly earthy, disappearing on heating; of No. 10804, none, becoming very faintly vegetable on h[eat]ing; of the remaining samples, none. —— The samples were collected from a faucet in a house in [the] easterly part of Watertown.

WATERTOWN AND BELMONT.

Microscopical Examination of Water from a Faucet in Watertown, supplied from the Works of the Watertown Water Supply Company.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	24	24	21	19	18	14	15	16	16	20	23	23
Number of sample,	9913	10040	10142	10260	10409	10513	10663	10804	11035	11219	11365	11534
PLANTS.												
Cyanophyceæ, Rivularia,	0	0	0	0	0	4	0	3	0	1	0	0
Fungi, Crenothrix,	0	0	0	0	0	0	0	0	92	0	1	0
ANIMALS.												
Infusoria, Peridinium,	0	0	0	1	0	0	0	0	0	0	1	0
Miscellaneous, Zoöglœa,	0	10	530	0	0	1	0	0	56	pr.	0	0
TOTAL,	0	10	530	1	0	5	0	3	148	1	2	0

Chemical Examination of Water from Tubular Test Wells in the Vicinity of the Pumping Station of the Watertown Water Supply Company.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9935	Jan. 25	None.	None.	0.00	6.80	.0000	.0018	.62	.0650	.0000	.0292	2.6	.0050
10418	May 16	Slight, milky.	Slight, rusty.	0.60	9.10	.0240	.0104	.58	.0030	.0003	.2993	3.8	.0760*
10550	June 21	None.	Slight, earthy.	0.25	7.30	.0220	.0108	.56	.0000	.0000	.3041	3.6	.0100
10619	July 8	Slight, milky.	Slight, white.	0.25	8.30	.0196	.0076	.55	.0000	.0000	.2336	4.2	.0180
10667	July 17	None.	None.	0.20	8.80	.0230	.0084	.56	.0000	.0001	.3120	3.9	.0320
11237	Oct. 23	V. slight.	None.	0.55	8.95	.0282	.0162	.68	.0000	.0000	.3192	3.9	.0110

* This sample contained also 0.1760 part manganese.

Odor of the first three samples, none; of the last three, mouldy or unpleasant; on heating, the odor of the second sample was distinctly vegetable, and of the last two, faintly vegetable.—— The first sample was collected from a group of tubular wells located a short distance northwest of the pumping station; the second and third, from a flowing well two inches in diameter, located about one thousand feet southeasterly from the pumping station and about seventy-five feet from Charles River; the last three, from six-inch tubular wells, located about nine hundred and fifty feet southeast of the pumping station and about forty feet from the river. Water was pumped from these six-inch wells into the filter-gallery in the summer and autumn of 1893.

WATERTOWN AND BELMONT.

Microscopical Examination.

No. 10418. Diatomaceæ, *Melosira*, 3; *Tabellaria*, 2. Fungi, *Crenothrix*, 34. Miscellaneous, *Zoöglœa*, 24. Total, 63.

No. 10667. Fungi, *Crenothrix*, 10. Miscellaneous, *Zoöglœa*, 2. Total, 12.

No organisms were found in the remaining samples.

Bacterial Examination.

Three samples of water collected on June 30 from the two-inch flowing well from which Nos. 10418 and 10550 were collected, contained an average of five bacteria per cubic centimeter, the highest number found being seven and the lowest two.

Three samples of water collected on July 17 from the six-inch tubular wells contained an average of four bacteria per cubic centimeter.

These wells were examined again on October 23, two samples being collected, each of which contained four bacteria per cubic centimeter.

Chemical Examination of Water from Deep Tubular Wells in Watertown.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
10252*	Apr. 11	Decided, clayey.	Heavy, clayey.	0.0	44.50	.0020	.0012	1.34	.0000	.0000	.0255	17.9	.0020
10530	June 19	Slight, clayey.	Slight, earthy.	0.0	22.40	.0018	.0000	1.65	.0030	.0000	.0100	6.3	.0000

* All determinations of this sample were made on the filtered water.

Odor of the first sample, faintly earthy; of the last, none.——The first sample was collected from a tubular well eight inches in diameter and about 250 feet in depth, located about fifty feet south of the pumping station of the Watertown Water Supply Company; the last, from a deep tubular well located near the centre of the main village of Watertown and near the railroad station. It is said that 160,000 gallons of water were pumped from the latter well in the twenty-six hours previous to the collection of the sample.

Microscopical Examination.

No organisms.

Water Supply of Webster.

Description of Works.—Population in 1890, 7,031. The works are owned by the town and water was introduced Jan. 1, 1894. The town had been supplied for many years previous to this time from works owned by H. L. Slater, the source of supply being Lake Chaubunagungamaug. The new source of supply is a well twenty-five feet in diameter and thirty feet in depth, located on the northwesterly side of the lake, about 200 feet from the shore. The wall of the well is made of stone, laid without mortar, for a height of three feet above the bottom, and above this level also of stone,

but with an interior lining of brick masonry twelve inches in thickness. The ground about the well is two or three feet higher than the water in the lake. The well is covered by a conical roof to exclude the light. Water is pumped from the well to the town and to an open iron tank thirty feet in diameter and 100 feet in height. Distributing mains are of cast-iron; service pipes are of wrought iron lined with cement.

The advice of the State Board of Health to the town of Webster with regard to taking a water supply from this source may be found on page 62 of this volume.

Chemical Examination of Water from a Tubular Test Well in Webster.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1892.												
10618	July 7	Slight, clayey.	Cons., earthy.	0.0	5.80	.0000	.0000	.23	.0400	.0000	.0000	0.8	.0150

Odor, none.——The sample was collected from a test well located about 1,700 feet north of Lake Street and two hundred feet from Lake Chaubunagungamaug, near where the large well was subsequently located.

Microscopical Examination.

No organisms.

Water Supply of Wellesley.

Chemical Examination of Water from the Filter-Gallery and Well of the Wellesley Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1892.												
10633	July 11	None.	V. slight.	0.0	6.70	.0000	.0008	.52	.0600	.0000	.0657	2.8	.0050
10634	July 11	None.	V. slight.	0.0	5.90	.0000	.0014	.60	.0600	.0000	.0657	2.3	.0100

Odor, none.——The first sample was collected from the filter-gallery; the last, from the well at Williams Spring.

Microscopical Examination.

No. 10633. Miscellaneous, *Zoöglœa*, 1.

No. 10634. No organisms.

WESTBOROUGH.

WATER SUPPLY OF WESTBOROUGH.

The advice of the State Board of Health to the town of Westborough, with reference to increasing the supply of filtered water from the Lower Sandra Basin by facilitating the filtration of water from the Upper Basin into it through the intervening ground may be found on page 63 of this volume.

WATER SUPPLY OF WESTBOROUGH INSANE HOSPITAL, WESTBOROUGH.

Chemical Examination of Water from the Tubular Wells at the Westborough Insane Hospital.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
	1893.												
9936	Jan. 25	Slight, milky.	None.	0.42	11.15	.0846	.0056	.42	.0030	.0001	.1181	5.8	.1300
10162	Mar. 27	Distinct, milky.	None.	0.80	11.15	.0564	.0068	.41	.0280	.0001	.0847	6.0	.1100
10444	May 24	Slight, milky.	V. slight.	0.40	10.95	.0720	.0050	.37	.0000	.0000	.1575	5.4	.0675
10678	July 18	Slight, milky.	V. slight.	0.18	11.10	.0900	.0050	.40	.0000	.0001	.1248	5.8	.0780
Av.	....	....	....	0.33	11.09	.0758	.0056	.40	.0078	.0001	.1200	5.8	.0964

Averages of Analyses of Previous Years.

-	1887*	-	-	0.08	11.29	.0407	.0033	.42	.0080	-	-	-	-
-	1888	-	-	0.06	11.27	.0502	.0051	.42	.0045	.0000	-	-	-
-	1889†	-	-	0.16	11.41	.0530	.0049	.43	.0030	.0000	-	-	-
-	1891‡	-	-	0.50	11.80	.0784	.0109	.43	.0040	.0000	-	6.0	-
-	1893	-	-	0.33	11.09	.0758	.0056	.40	.0078	.0001	.1200	5.8	.0964

* June to December. † January to May. ‡ July, two samples.

NOTE to analyses of 1893; Odor of the first sample, none, becoming distinctly vegetable and grassy on heating; of the second sample, offensive, disappearing on heating; of the remaining samples, none. — The samples were collected from a faucet at the pumping station while pumping.

Iron in considerable amount is characteristic of the water of these wells. It oxidizes promptly on exposure to the air and precipitates, causing first a milky turbidity and then a rusty precipitate. Somewhat similar conditions exist in the water supplies of Reading, Bradford and other places.

Microscopical Examination.

The organisms found in these samples in 1893 were chiefly Zoöglœa, the greatest number, 124, being present in January, and the smallest, 6, in May.

WESTFIELD.

Water Supply of Westfield.

Chemical Examination of Water from the Storage Reservoir of the Westfield Water Works, on Moose Meadow Brook, Montgomery.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10942	Aug. 31	Distinct.	Slight.	0.75	3.00	1.60	.0000	.0222	.0174	.0048	.09	.0000	.0000	0.6063	0.2
11260	Oct. 27	Slight.	Cons.	1.20	3.40	1.50	.0010	.0220	.0170	.0050	.16	.0020	.0000	1.0092	0.5

Iron, .0276. Odor of the first sample, faintly vegetable, becoming stronger on heating; of the last, distinctly earthy, becoming vegetable on heating.——The samples were collected from the reservoir.

Microscopical Examination.

No. 10942. Diatomaceæ, *Asterionella*, 1,920; *Cocconeis*, 40; *Cocconema*, 1; *Cyclotella*, 2; *Diatoma*, 64; *Synedra*, 80. Cyanophyceæ, *Spores*, 1. Algæ, *Chlorococcus*, 9; *Raphidium*, 4; *Staurastrum*, 2. Fungi, *Crenothrix*, 1. Rhizopoda, *Arcella*, 3; *Difflugia*, 2. Infusoria, *Peridinium*, 24; *Trachelomonas*, 3. Vermes, *Anuræa*, 2; *Monocerca*, 1; *Polyarthra*, 1. Miscellaneous, *Zoöglœa*, 84. Total, 2,244.

No. 11260. Diatomaceæ, *Asterionella*, 144; *Navicula*, 1; *Synedra*, 1; *Tabellaria*, 128. Algæ, *Scenedesmus*, 1; *Staurastrum*, 1; *Zoöspores*, 1. Fungi, *Crenothrix*, 24. Infusoria, *Trachelomonas*, 5. Miscellaneous, *Zoöglœa*, 32. Total, 338.

Chemical Examination of Water from the Distributing Reservoir of the Westfield Water Works, on Moose Meadow Brook, Montgomery.

[Parts per 100,000.]

Iron, .0098. Odor of the first sample, distinctly mouldy; of the second, distinctly vegetable and sweetish; of the last, faintly vegetable.——The samples were collected from the lower or distributing reservoir in Montgomery. Water flows from the storage to the distributing reservoir, a distance of a little more than two miles, in the open channel of the brook, falling more than 400 feet in its course from the storage reservoir. The lower reservoir has a drainage area of two and one-quarter square miles in addition to that of the storage reservoir.

Microscopical Examination of Water from the Distributing Res
Westfield Water Works.

[Number of organisms per cubic centimeter.]

	1893.	
	June.	Septemb
Day of examination,	27	2
Number of sample,	10564	10943
PLANTS.		
Diatomaceæ,	**182**	**9**
Asterionella,	32	5
Diatoma,	8	0
Epithemia,	2	0
Navicula,	pr.	2
Pinnularia,	pr.	1
Synedra,	14	1
Tabellaria,	126	0
Algæ,	**2**	**19**
Arthrodesmus,	0	2
Chlorococcus,	0	7
Protococcus,	0	10
Staurastrum,	0	0
Zoöspores,	2	0
Fungi, Crenothrix,	**20**	**64**
ANIMALS.		
Infusoria,	**19**	**2**
Dinobryon cases,	5	0
Peridinium,	14	2
Trachelomonas,	0	0
Miscellaneous, Zoöglœa,	**18**	**64**
TOTAL,	241	158

WESTFIELD.

Chemical Examination of Water from a Faucet in Westfield, supplied from the Westfield Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
10041	Feb. -*	V. slight.	V. slight.	0.50	2.75	0.75	.0014	.0120	.0084	.0036	.12	.0090	.0000	.4437	0.9
10334	Apr. 29	V. slight.	Slight.	0.35	1.85	1.00	.0000	.0114	.0076	.0038	.08	.0050	.0001	.3723	0.2
11561	Dec. 29	V. slight.	Slight.	0.40	2.65	0.90	.0000	0082	.0072	.0010	.13	.0300	.0000	.3927	1.4
Av. .	....	....	....	0.42	2.42	0.88	.0005	.0105	.0077	.0028	.11	.0147	.0000	.4029	0.8

* Received in laboratory February 25.

Iron, .0088. Odor, faintly vegetable. —— The samples were collected from a faucet in the town.

Microscopical Examination of Water from a Faucet in Westfield, supplied from the Westfield Water Works.

[Number of organisms per cubic centimeter.]

	1893.		1894.
	February.	May.	January.
Day of examination,	28	2	1
Number of sample,	10041	10334	11561
PLANTS.			
Diatomaceæ,	13	17	4
Asterionella,	pr.	1	1
Cyclotella,	3	pr.	0
Diatoma,	1	pr.	0
Epithemia,	pr.	3	1
Meridion,	2	4	pr.
Navicula,	3	2	pr.
Nitzschia,	2	0	0
Synedra,	0	1	2
Tabellaria,	2	6	pr.
Algæ, Zoöspores,	4	18	0
ANIMALS.			
Infusoria,	14	44	1
Dinobryon cases,	0	4	0
Peridinium,	14	40	1
Miscellaneous, Zoöglœa,	88	5	0
TOTAL,	119	84	5

Water Supply of West Springfield.

The town of West Springfield extended its works in 1893 with a view to supplying water to the village of Mittineague, which is situated at too great an elevation to be supplied with water from the existing works. The new source of supply is a well twenty-five feet in diameter and fourteen feet deep, located at the Craig Spring, a short distance below the storage reservoir. The well is supplied in part by the numerous springs in its vicinity, the water of which is collected by means of small pipes into a main pipe which carries it to a settling well and thence to the main well. Water is pumped from this well by means of a windmill to a tank at Mittineague. The advice of the State Board of Health to the town of West Springfield relative to an additional water supply for the town may be found on page 65.

Chemical Examination of Water from Various Sources, collected during an Investigation for an Additional Water Supply for West Springfield.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10403	May 16	V. slight.	Slight.	0.12	5.60	1.30	.0002	.0114	.0100	.0014	.09	.0120	.0000	.2518	3.2
10400	May 16	None.	None.	0.00	5.80	-	.0000	.0008	-	-	.13	.0380	.0000	.0328	3.5
10401	May 16	V. slight.	Cons., sand.	0.04	3.45	0.80	.0000	.0024	.0018	.0006	.21	.0600	.0000	.0766	1.8
10402	May 16	V. slight.	V. slight.	0.04	8.10	1.00	.0000	.0040	.0032	.0008	.11	.0000	.0000	.0949	5.7
10404	May 16	V. slight.	Slight.	0.30	4.00	1.55	.0000	.0096	.0078	.0018	.10	.0070	.0001	.3759	1.8
10443	May 23	V. slight.	Slight, dark.	0.00	5.10	-	.0000	.0024	-	-	.39	.1800	.0000	.0600	1.5

Iron, .0041. Odor of the first and fourth samples, distinctly vegetable and grassy, becoming faintly vegetable on heating; of the second and third, none; of the last two, very faintly vegetable. —— The first sample was collected from Bear Hole Brook, in the northwesterly part of West Springfield, near the Massasoit Spring, and about two miles below the outlet of Ashley Pond; the second, from the Massasoit Spring; the third, from Leonard Brook in Agawam, about half a mile above its mouth. This brook is a very small tributary of the Westfield River, and enters it from the south at the first bridge above its mouth. The fourth sample was collected from Lathrop Brook in West Springfield, a small tributary of Block Brook, entering it about a mile and a half from its mouth; the fifth sample from Hyde Brook in West Springfield, at the point where it is crossed by a road leading from Mittineague to Prospect Hill; and the last sample from the Craig Spring, which is now used to supply the village of Mittineague.

Microscopical Examination of Water from Various Sources collected during an Investigation for an Additional Water Supply for West Springfield.

[Number of organisms per cubic centimeter.]

	1896.					
	May.	May.	May.	May.	May.	May.
Day of examination,	18	18	18	18	18	25
Number of sample,	10408	10400	10401	10402	10404	10448
PLANTS.						
Diatomaceæ,	26	2	12	3	5	21
Asterionella,	2	0	0	0	0	0
Cocconema,	0	0	0	0	0	3
Cyclotella,	1	0	0	0	0	0
Cymbella,	2	0	0	0	pr.	0
Diatoma,	0	0	1	1	1	14
Fragilaria,	1	0	0	0	0	0
Melosira,	0	1	0	0	1	0
Meridion,	0	0	2	0	1	0
Navicula,	0	0	8	pr.	1	2
Stauroneis,	0	0	0	0	0	2
Synedra,	16	1	0	2	1	0
Tabellaria,	4	0	0	0	0	0
Algæ, Staurastrum,	0	0	0	2	pr.	0

Chemical Examination of Water from Faucets in Weymouth, etc.— Con

Averages of Analyses of Previous Years.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as	
								Albuminoid.					
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.
-	1887*	-	-	0.93	4.08	1.75	.0007	.0219	-	-	.47	.0080	-
-	1888†	-	-	0.88	4.15	1.94	.0020	.0225	-	-	.48	.0074	.0000
-	1889‡	-	-	1.40	-	-	.0000	.0230	.0220	.0010	-	.0040	.0000
-	1892	-	-	0.94	3.82	1.86	.0000	.0173	.0156	.0017	.51	.0077	.0000
-	1893	-	-	0.76	3.86	1.66	.0003	.0163	.0139	.0025	.57	.0008	.0000

* June to December. † January to May. ‡ July.

NOTE to analyses of 1893; Iron, .0182. Odor of the first sample, distinctly vegetable; of tl and last samples, faintly vegetable; of the third sample, none.—— The samples were collec faucets in the town.

Microscopical Examination.

Very few organisms were found in any of these samples.

WATER SUPPLY OF WHITMAN.

The advice of the State Board of Health to the town of Whi with reference to taking an additional supply of water for that from ponds in Pembroke, Hanson and neighboring towns, m found on page 67 of this volume.

For analyses of samples of water from the various ponds tioned in the reply of the Board, see *Abington*, *Hanson* and *broke*. Analyses of samples of water from the present sourc supply are given below.

Chemical Examination of Water from the Filter-Gallery of the Whitm Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.		
	1893.											
10178	Mar. 28	V. slight.	Slight.	0.25	3.50	.0022	.0068	.60	.0150	.0000	.3175	1.3
10566	June 27	Distinct.	Slight.	1.10	6.70	.0032	.0322	.83	.0000	.0000	.8216	1.9
11057	Sept. 20	Distinct, milky.	Slight.	0.18	6.90	.0028	.0238	.99	.0050	.0001	.5248	2.2
Av...	....	....	....	0.51	5.70	.0027	.0209	.81	.0067	.0000	.5546	1.8

WHITMAN.

Chemical Examination of Water from the Filter-Gallery of the Whitman Water Works — Concluded.

Averages of Analyses of Previous Years.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.
		Turbidity.	Sediment.	Color.		Free.	Albuminoid.		Nitrates.	Nitrites.			
-	1887*	-	-	0.85	7.25	.0142	.0267	.76	.0195	-	-	-	-
-	1888†	-	-	0.23	5.87	.0123	.0192	.71	.0203	.0006	-	-	-
-	1889	-	-	0.30	4.66	.0095	.0155	.68	.0148	.0004	-	-	-
-	1890	-	-	0.25	5.82	.0048	.0142	.78	.0177	.0001	-	2.1	-
-	1891	-	-	0.45	5.64	.0067	.0184	.68	.0137	.0001	-	1.9	-
-	1893	-	-	0.51	5.70	.0027	.0209	.81	.0067	.0000	.5546	1.8	.0402

* August and October. † July to December.

NOTE to analyses of 1893; Odor of the first two samples, vegetable; of the last, none.—— The samples were collected from the filter-gallery.

Microscopical Examination of Water from the Filter-Gallery of the Whitman Water Works.

[Number of organisms per cubic centimeter.]

	1893.		
	March.	June.	September.
Day of examination,	29	27	21
Number of sample,	10178	10566	11057
PLANTS.			
Diatomaceæ,	4	0	2
Synedra,	4	0	0
Tabellaria,	0	0	2
Algæ, Protococcus,	0	4	0
ANIMALS.			
Rhizopoda,	0	3	1
Actinophrys,	0	3	0
Difflugia,	0	0	1
Infusoria,	41	1	24
Dinobryon cases,	0	0	12
Peridinium,	41	0	11
Trachelomonas,	0	1	1
Vermes,	0	2	0
Anuræa,	0	1	0
Rotifer cases,	0	1	0
Miscellaneous, Zoöglœa,	10	0	0
TOTAL,	55	10	27

WHITMAN.

Chemical Examination of Water from Hobart's Pond, Whitman.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
10177	Mar. 28	Slight.	Slight.	0.50	3.75	1.15	.0008	.0174	.0146	.0028	.61	.0180	.0000	.4745	1.1
10565	June 27	Distinct, green.	Slight.	1.10	6.85	2.50	.0010	.0392	.0330	.0062	.82	.0000	.0000	.8176	1.8
11056	Sept. 20	Slight.	Slight.	0.40	6.25	2.80	.0008	.0362	.0340	.0022	.98	.0000	.0000	.6396	1.9
Av.	....	....	....	0.67	5.62	2.15	.0009	.0309	.0272	.0037	.80	.0060	.0000	.6439	1.6

Averages of Analyses of Previous Years.

Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Residue Total.	Loss on Ignition.	Ammonia Free.	Albuminoid Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.
-	1887*	-	-	1.43	7.87	2.48	.0127	.0600	-	-	.80	.0063	-	-	-
-	1888	-	-	1.02	6.01	2.20	.0051	.0407	-	-	.70	.0133	.0002	-	-
-	1889	-	-	0.89	5.11	1.80	.0037	.0392	.0327	.0065	.71	.0089	.0002	-	-
-	1890	-	-	0.57	6.11	2.54	.0027	.0319	.0257	.0062	.69	.0186	.0002	-	2.0
-	1891	-	-	0.64	5.34	2.02	.0012	.0334	.0273	.0061	.68	.0112	.0001	-	1.6
-	1893	-	-	0.67	5.62	2.15	.0009	.0309	.0272	.0037	.80	.0060	.0000	.6439	1.6

* June, July, October and December.

NOTE to analyses of 1893; Iron, .0183. Odor, vegetable, becoming unpleasant in the first two samples on heating.——The samples were collected from the pond near the outlet.

Microscopical Examination of Water from Hobart's Pond, Whitman.

[Number of organisms per cubic centimeter.]

	1893. March.	1893. June.	1893. September.
Day of examination,	29	27	21
Number of sample,	10177	10565	11056
PLANTS.			
Diatomaceæ,	29	12	0
Diatoma,	8	0	0
Melosira,	0	8	0
Meridion,	3	0	0
Synedra,	14	3	0
Tabellaria,	4	1	0
Algæ,	11	3	44
Chlorococcus,	11	0	1
Protococcus,	0	0	43
Staurastrum,	0	3	0
Fungi, Crenothrix,	1	3	0

Microscopical Examination of Water from Hobart's Pond — Concluded.

[Number of organisms per cubic centimeter.]

	1892.		
	March.	June.	September.
ANIMALS.			
Rhizopoda,	**0**	**32**	**3**
Actinophrys,	0	32	0
Difflugia,	0	0	3
Infusoria,	**26**	**20**	**3**
Dinobryon cases,	1	11	2
Peridinium,	24	8	1
Trachelomonas,	1	1	0
Vermes,	**0**	**14**	**0**
Anurea,	0	7	0
Rotifer cases,	0	7	0
Miscellaneous, Zoöglœa,	12	56	6
TOTAL,	38	140	40

WATER SUPPLY OF WINCHESTER.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works.

WINCHESTER.

Chemical Examination of Water from the North Reservoir of the Winchester Water Works — Concluded.

Averages of Analyses of Previous Years.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
-	1887*	-	-	.11	5.08	1.18	.0015	.0196	-	-	.53	.0037	-	-	-
-	1888	-	-	.15	4.93	1.24	.0045	.0278	-	-	.47	.0131	.0003	-	-
-	1889	-	-	.13	4.52	1.18	.0022	.0223	.0176	.0047	.47	.0105	.0003	-	-
-	1890	-	-	.09	5.30	1.31	.0017	.0201	.0160	.0041	.52	.0153	.0002	-	2.7
-	1891	-	-	.10	4.94	1.39	.0034	.0222	.0169	.0053	.51	.0152	.0001	-	2.1
-	1892	-	-	.06	5.23	1.59	.0058	.0217	.0177	.0040	.60	.0192	.0002	-	2.5
-	1893	-	-	.07	5.18	1.62	.0055	.0252	.0172	.0080	.59	.0127	.0002	.2718	2.3

* June to December.

NOTE to analyses of 1893: Iron, .0057. Odor, vegetable, occasionally mouldy or unpleasant. — The samples were collected from the North Reservoir, near the gate-house, about one foot beneath the surface.

Microscopical Examination of Water from the North Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1893.					
	Jan.	March.	May.	June.	Sept.	Nov.
Day of examination,	5	7	4	11	9	9
Number of sample,	9851	10080	10351	10622	10980	11293
PLANTS.						
Diatomaceæ,	42	2	5,764	0	8	171
Asterionella,	0	0	2,800	0	8	93
Cyclotella,	1	0	118	0	0	60
Fragilaria,	0	0	104	0	0	0
Melosira,	0	2	0	0	0	16
Synedra,	1	0	2,488	0	0	1
Tabellaria,	40	0	254	0	0	1
Cyanophyceæ,	1,268	0	42	1	2	37
Anabæna,	0	0	2	0	0	7
Chroöcoccus,	1,268	0	0	0	0	0
Clathrocystis,	0	0	0	1	2	1
Cœlosphærium,	0	0	0	0	0	19
Hapalosiptron,	0	0	40	0	0	0
Microcystis,	0	0	0	0	0	10
Algæ,	7	0	60	120	23	45
Chlorococcus,	3	0	6	0	7	12
Closterium,	0	0	32	74	1	1
Hyalotheca,	4	0	0	0	0	0
Protococcus,	0	0	21	46	5	30
Raphidium,	0	0	0	0	8	0
Staurastrum,	0	0	1	0	2	2

WINCHESTER.

Microscopical Examination of Water from the North Reservoir of the Winchester Water Works — Concluded.

[Number of organisms per cubic centimeter.]

	1893.					
	Jan.	March.	May.	June.	Sept.	Nov.
ANIMALS.						
Rhizopoda, Actinophrys, . . .	3	0	4	0	0	0
Infusoria, ...	7	3	92	0	1,149	66
Dinobryon, ...	0	0	66	0	0	0
Dinobryon cases, ...	1	0	2	0	1,120	36
Peridinium, ...	6	0	15	0	1	0
Trachelomonas, ...	0	3	pr.	0	28	17
Vorticella, ...	0	0	9	0	0	13
Vermes, Rotifer, ...	0	0	0	1	0	0
Crustacea, Cyclops, ...	0	.10	0	0	0	0
Miscellaneous, ...	0	.01	5	18	72	27
Acarina, ...	0	.01	.04	0	.01	0
Zoöglœa, ...	0	0	5	18	72	27
TOTAL, ...	1,327	5	5,967	140	1,254	346

Chemical Examination of Water from the South Reservoir of the Winchester Water Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9852	Jan. 4	Slight.	Slight.	.45	3.85	1.65	.0156	.0230	.0146	.0084	.26	.0150	.0002	-	1.8
10081	Mar. 6	V. slight.	Slight.	.55	5.35	2.05	.0066	.0354	.0124	.0230	.42	.0180	.0000	.5256	2.3
10352	May 3	Distinct.	Cons., green.	.40	5.15	1.95	.0052	.0262	.0232	.0030	.34	.0150	.0005	.4562	1.9
10623	July 10	Distinct.	Slight, green.	.15	4.80	2.00	.0000	.0324	.0278	.0046	.39	.0000	.0000	.4161	2.1
10981	Sept. 7	V. slight, green.	V. slight.	.18	4.65	1.70	.0022	.0304	.0276	.0028	.38	.0030	.0001	.5080	2.1
11292	Nov. 6	Slight.	Cons., green.	.33	4.90	1.80	.0090	.0270	.0238	.0032	.39	.0050	.0004	.5395	2.2
Av.	....	....	....	.34	4.78	1.86	.0064	.0291	.0216	.0075	.36	.0093	.0002	.4891	2.1

Averages of Analyses of Previous Years.

-	1891*	-	-	.60	5.73	2.09	.0110	.0486	.0361	.0125	.40	.0094	.0006	-	2.3
-	1892	-	-	.51	5.17	2.04	.0055	.0392	.0318	.0074	.38	.0118	.0002	-	2.2
-	1893	-	-	.34	4.78	1.86	.0064	.0291	.0216	.0075	.36	.0093	.0002	.4891	2.1

* August to December.

NOTE to analyses of 1893; Iron, .0317. Odor, vegetable, becoming stronger and frequently unpleasant on heating.——The samples were collected from the reservoir near the gate-house, from six inches to three feet beneath the surface.

WINCHESTER.

Microscopical Examination of Water from the South Reservoir of the Winchester Water Works.

[Number of organisms per cubic centimeter.]

	1898.					
	Jan.	March.	May.	July.	Sept.	Nov.
Day of examination,	5	7	4	11	9	8
Number of sample,	9852	10081	10352	10623	10981	11292
PLANTS.						
Diatomaceæ,	15	1	524	pr.	2	461
Asterionella,	4	0	430	0	0	132
Cyclotella,	1	1	0	0	0	1
Melosira,	4	0	0	0	0	0
Stephanodiscus,	5	0	0	0	0	0
Synedra,	1	pr.	94	pr	0	0
Tabellaria,	0	0	0	0	2	328
Cyanophyceæ,	0	0	0	114	14	36
Anabæna,	0	0	0	88	4	1
Anabæna spores,	0	0	0	0	0	30
Clathrocystis,	0	0	0	2	10	1
Microcystis,	0	0	0	0	0	4
Oscillaria,	0	0	0	24	0	0
Algæ,	0	3	0	182	288	10
Chlorococcus,	0	0	0	0	0	3
Closterium,	0	3	0	180	288	2
Protococcus,	0	0	0	2	0	5
ANIMALS.						
Infusoria,	1	4	181	0	148	7
Dead infusoria,	0	0	2	0	0	0
Dinobryon,	0	0	178	0	0	0
Dinobryon cases,	0	0	1	0	144	0
Euglena,	0	0	0	0	0	1
Peridinium,	1	0	0	0	2	0
Trachelomonas,	0	4	pr.	0	2	4
Vorticella,	0	0	0	0	0	2
Vermes,	0	1	3	1	0	2
Anurea,	0	1	0	1	0	1
Monocerca,	0	0	0	0	0	1
Rotatorian ova,	0	pr.	1	0	0	0
Sacculus,	0	0	2	0	0	0
Miscellaneous, Zoöglœa,	0	0	116	36	21	116
TOTAL,	16	9	824	309	473	632

WOBURN.

Chemical Examination of Water from Horn Pond, Woburn.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity	Sediment	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
9924	Jan. 24	Distinct.	Heavy, green.	.40	13.60	3.20	.0008	.0842	.0310	.0532	3.08	.0950	.0005	.5402	3.9
10155	Mar. 22	Distinct.	Slight.	.40	4.75	1.85	.0134	.0208	.0158	.0050	0.67	.0300	.0000	.4140	1.8
10173	Mar. 27	Decided, green.	Slight, green.	.60	6.30	2.40	.0118	.0190	.0164	.0026	0.86	.0300	.0001	.4161	1.9
10311	Apr. 25	Slight.	Heavy, green.	.40	9.65	2.10	.0006	.0484	.0240	.0244	2.29	.0800	[illegible]	.4348	2.9
10452	May 24	Distinct.	Cons.	.50	8.45	2.70	.0076	.0258	.0176	.0082	1.64	.0700	.0009	.5400	2.6
10532	June 21	Distinct.	Cons., green.	.30	9.40	3.05	.0074	.0338	.0230	.0108	1.97	.0700	.0028	.4503	2.8
10657	July 19	Decided.	Cons.	.20	10.25	2.85	.0082	.0858	.0482	.0376	2.08	.0400	.0008	.3996	3.2
10876	Aug. 23	Decided, green.	Slight, green.	.30	10.56	2.75	.0000	.0544	.0268	.0276	2.31	.0050	.0008	.4424	3.3
11075	Sept. 20	Decided, green.	Cons., green.	.12	10.05	2.30	.0030	.0660	.0266	.0394	2.19	.0070	.0003	.4264	3.5
11210	Oct. 17	Slight.	Slight.	.18	10.75	2.60	.0170	.0314	.0238	.0076	2.43	.0090	.0008	.4131	3.8
11378	Nov. 22	Distinct.	Slight.	.15	10.00	1.75	.0004	.0278	.0164	.0114	2.37	.0180	.0009	.4704	3.5
11563	Dec. 26	Slight.	Slight.	[illegible]	9.60	2.15	.0004	.0232	.0182	.0050	2.04	.0700	.0000	.4880	3.4
Av.	....	....	....	.30	9.83	2.51	.0061	.0455	.0247	.0208	2.10	.0472	.0009	.4630	3.2

Averages of Analyses of Previous Years.

-	1887*	-	-	.44	13.79	2.19	.0149	.0480	-	-	3.74	.0224	.0014	-	-
-	1888	-	-	.32	11.28	1.71	.0184	.0383	-	-	2.98	.0398	.0015	-	-
-	1889	-	-	[illegible]	8.87	2.03	.0092	.0376	.0216	.0160	1.98	.0498	.0015	-	-
-	1890	-	-	.27	10.76	2.07	.0060	.0368	.0205	.0163	1.91	.0581	.0008	-	3.4
-	1891	-	-	.22	8.90	2.06	.0129	.0453	[illegible]	.0216	1.76	.0502	.0009	-	2.9
-	1892	-	-	.25	10.67	2.13	.0110	.0358	.0216	.0142	2.42	.0821	.0008	-	3.3
-	1893	-	-	.30	9.83	2.51	.0061	.0455	.0247	.0208	2.10	.0472	.0009	.4630	3.2

* June to December.

NOTE to analyses of 1893: Iron, .0078. Odor, distinctly vegetable and frequently unpleasant; on heating, the odor is generally stronger and frequently also disagreeable. —— The first two samples were collected from the pond about one hundred feet from the shore near the pumping station of the Woburn Water Works; the remaining samples from the pond near its outlet. The samples were collected about one foot beneath the surface.

WORC

Water Supply of Worcester.

. During the past year the raising of the dam of the E storage reservoir has been completed and the capacity of the voir increased by nearly 300,000,000 gallons. The work con of strengthening the dam on the lower side by widening its bas increasing its height to a level of ten feet above the old dam, ing the latter to form a berme in the completed structure. Th of the reservoir is now 149.5 acres, and its capacity 742,00 gallons. Its greatest depth is 30.1 feet and its average depth 15.2 feet. The area newly flowed has been prepared by rem the trees and bushes and much other objectionable material, an covering the swampy places with gravel.

Leicester Supply — *Chemical Examination of Water from the Lynde B Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.	
								Total.	Dissolved.	Suspended.				
	1893.													
9908	Jan. 20	Slight.	Slight.	0.45	3.40	1.10	.0062	.0140	.0126	.0014	.13	.0050	.0001	.430
10000	Feb. 14	Distinct.	Slight.	0.30	2.70	1.10	.0010	.0240	.0138	.0102	.16	.0050	.0001	.430
10139	Mar. 16	Slight, clayey.	Slight.	0.33	2.70	1.10	.0030	.0146	.0116	.0030	.15	.0100	.0000	.334
10388	May 15	V. slight.	Slight.	0.20	2.50	0.90	.0000	.0134	.0110	.0024	.11	.0150	.0001	.310
10531	June 19	Distinct.	Cons., yellow.	0.20	2.35	1.00	.0014	.0232	.0168	.0064	.16	.0030	.0000	.321
10669	July 17	V. slight.	Slight.	0.05	2.50	1.25	.0004	.0186	.0134	.0052	.15	.0030	.0000	.304
10872	Aug. 22	Slight.	Slight, white.	0.10	2.45	1.35	.0000	.0122	.0106	.0016	.15	.0000	.0000	.3002
11042	Sept. 18	Slight.	Slight, yellow.	0.15	2.60	0.15	.0004	.0158	.0130	.0028	.18	.0000	.0000	.3276
11200	Oct. 16	Distinct.	Cons.	0.42	2.75	1.05	.0094	.0162	.0114	.0048	.14	.0050	.0000	.3199
11352	Nov. 20	Slight.	Slight.	0.48	2.95	1.00	.0102	.0142	.0104	.0038	.15	.0070	.0001	.4158
11512	Dec. 18	Slight.	V. slight.	0.20	2.35	0.75	.0072	.0116	.0100	.0016	.14	.0200	.0004	.3159
Av.	....	....	....	0.26	2.66	0.98	.0036	.0162	.0122	.0039	.15	.0066	.0001	.3465

Averages of Analyses of Previous Years.

-	1887*	-	-	0.30	3.15	0.95	.0057	.0194	-	-	.15	.0043	-	-
-	1888	-	-	0.24	2.64	0.85	.0037	.0151	-	-	.14	.0065	.0001	-
-	1889	-	-	0.24	2.54	0.60	.0030	.0167	.0138	.0029	.15	.0053	.0001	-
-	1890	-	-	0.21	3.07	1.15	.0026	.0132	.0107	.0025	.14	.0078	.0001	-
-	1891	-	-	0.24	2.83	1.03	.0045	.0126	.0101	.0025	.12	.0074	.0001	-
-	1892	-	-	0.25	2.99	1.15	.0038	.0139	.0113	.0026	.15	.0105	.0000	-
-	1893	-	-	0.26	2.66	0.98	.0036	.0162	.0122	.0039	.15	.0066	.0001	.3465

* June to December.

Note to analyses of 1893; Iron, .0219. Odor, vegetable, rarely unpleasant, sometimes none; heating, the odor is somewhat stronger and frequently unpleasant.——The samples were collec from the reservoir near the gate-house about one foot beneath the surface.

WORCESTER.

HOLDEN SUPPLY — *Chemical Examination of Water from the Tatnuck Brook Storage Reservoir.*

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9907	Jan. 20	Slight.	Slight.	0.40	2.90	1.00	.0030	.0124	.0108	.0016	.11	.0100	.0001	.4380	0.5
9999	Feb. 14	V. slight.	Slight.	0.30	2.90	0.95	.0096	.0150	.0128	.0022	.16	.0070	.0001	.2920	0.8
10138	Mar. 16	Slight, clayey.	Slight.	0.30	2.05	0.80	.0024	.0104	.0086	.0018	.14	.0070	.0000	.2916	0.5
10258	Apr. 17	Slight.	Slight.	0.15	2.55	1.00	.0000	.0062	.0048	.0014	.12	.0070	.0000	.2774	0.2
10399	May 15	Slight.	Cons.	0.20	1.95	0.65	.0004	.0176	.0144	.0032	.10	.0000	.0000	.3066	0.5
10532	June 19	Distinct.	Cons., white.	0.35	2.10	0.75	.0042	.0188	.0144	.0044	.17	.0050	.0000	.3417	0.5
10670	July 17	Slight.	Slight.	0.30	2.60	1.40	.0016	.0228	.0210	.0018	.14	.0030	.0000	.3666	0.1
10873	Aug. 22	Distinct, green.	Cons., green.	0.40	2.65	1.05	.0000	.0198	.0148	.0050	.14	.0080	.0000	.3713	0.5
11041	Sept. 18	Distinct.	Slight, yellow.	0.55	2.55	0.80	.0008	.0244	.0172	.0072	.12	.0030	.0000	.3627	0.6
11201	Oct. 16	Distinct.	Cons., green.	0.50	2.25	0.80	.0000	.0286	.0196	.0090	.16	.0000	.0000	.3807	1.1
11353	Nov. 20	Distinct.	Cons.	0.45	2.30	0.95	.0000	.0222	.0142	.0080	.16	.0060	.0000	.4746	0.6
11513	Dec. 18	Slight.	V. slight.	0.30	2.65	1.05	.0016	.0206	.0158	.0048	.16	.0080	.0001	.4090	0.5
Av.	....	....	....	0.35	2.45	0.93	.0020	.0182	.0140	.0042	.14	.0049	.0000	.3594	0.5

Averages of Analyses of Previous Years.

-	1887*	-	-	0.29	2.62	1.01	.0007	.0197	-	-	.14	.0016	-	-	-
-	1888	-	-	0.17	2.23	0.75	.0012	.0157	-	-	.12	.0043	.0001	-	-
-	1889	-	-	0.19	2.04	0.57	.0003	.0143	.0112	.0031	.12	.0031	.0001	-	-
-	1890	-	-	0.17	2.68	1.24	.0007	.0141	.0102	.0039	.13	.0078	.0001	-	0.9
-	1891	-	-	0.17	2.30	0.94	.0024	.0143	.0102	.0041	.11	.0077	.0001	-	0.4
-	1892	-	-	0.20	2.52	1.08	.0012	.0142	.0113	.0029	.12	.0067	.0000	-	0.5
-	1893	-	-	0.35	2.45	0.93	.0020	.0182	.0140	.0042	.14	.0049	.0000	.3594	0.5

* June to December.

NOTE to analyses of 1893; Iron, .0195. Odor, generally faintly vegetable, occasionally unpleasant, frequently none; on heating, the odor is much stronger and very frequently unpleasant. —— The samples were collected from the reservoir near the gate-house, one foot beneath the surface.

WORCESTER.

Microscopical Examination of Water from the Tatnuck Brook Storage Reservoir.

[Number of organisms per cubic centimeter.]

	1892.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	21	16	21	18	16	21	20	24	19	17	22	20
Number of sample,	9907	9999	10138	10258	10389	10532	10670	10873	11041	11201	11353	11513
PLANTS.												
Diatomaceæ,	8	51	1	80	1,115	28	4	2,140	2,442	1,485	927	4
Asterionella,	2	8	0	1	6	0	0	0	0	9	16	4
Cyclotella,	0	0	0	8	0	0	0	40	3	3	0	0
Melosira,	4	27	1	27	72	0	0	57	36	348	88	0
Meridion,	0	0	0	28	1	0	0	0	0	0	1	0
Navicula,	0	1	pr.	0	0	pr.	0	3	0	1	1	0
Synedra,	0	8	0	4	36	0	0	0	3	0	1	0
Tabellaria,	2	12	0	17	1,000	28	4	2,040	2,400	1,124	820	0
Cyanophyceæ, Anabæna,	0	0	0	0	0	0	2	6	0	0	0	0
Algæ,	0	0	0	pr.	6	0	102	224	30	61	63	0
Chlorococcus,	0	0	0	0	0	0	2	0	26	52	6	0
Gomphosphæria,	0	0	0	0	0	0	0	0	0	0	6	0
Pediastrum,	0	0	0	0	0	0	6	0	2	1	1	0
Protococcus,	0	0	0	0	4	0	6	220	0	0	44	0
Scenedesmus,	0	0	0	pr.	1	0	32	2	1	6	6	0
Staurastrum,	0	0	0	0	1	0	56	2	1	2	0	0
Fungi, Crenothrix,	0	1	0	0	0	2	0	0	0	3	0	0
ANIMALS.												
Infusoria,	10	7	1	5	64	1	2	6	17	11	0	1
Ciliated infusorian,	0	0	0	0	0	0	0	0	0	2	0	0
Dinobryon,	6	0	0	0	0	0	0	0	0	0	0	0
Dinobryon cases,	4	7	0	0	30	0	0	0	1	1	0	0
Encysted Protozoa,	0	0	0	0	2	0	0	0	0	0	0	0
Monas,	0	0	0	0	0	0	0	0	0	2	0	0
Peridinium,	0	0	1	5	32	1	0	6	14	2	0	1
Trachelomonas,	0	0	0	0	0	0	2	0	2	4	0	0
Vermes,	8	0	0	pr.	pr.	0	1	0	5	0	1	0
Anurea,	1	0	0	0	0	0	0	0	5	0	0	0
Rotatorian ova,	0	0	0	pr.	pr.	0	0	0	0	0	1	0
Rotifer,	7	0	0	0	0	0	1	0	0	0	0	0
Miscellaneous, Zoöglœa,	0	36	36	0	18	24	6	360	0	72	4	3
TOTAL,	26	95	38	85	1,208	55	117	2,736	2,494	1,632	995	8

WORCESTER.

Chemical Examination of Water from Hermitage Pond, Worcester.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1892.														
10668	July 17	Distinct.	Cons.	0.08	5.25	2.10	.0094	.0418	.0268	.0150	.31	.0030	.0002	.2886	2.1

Iron, .0125. Odor, faintly vegetable and unpleasant.—The sample was collected from the pond near the gate-house, one foot beneath the surface.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 54; *Cyclotella*, 1; *Epithemia*, 1; *Fragilaria*, 6; *Melosira*, 216; *Synedra*, 104. Cyanophyceæ, *Clathrocystis*, 14. Algæ, *Closterium*, 8; *Cosmarium*, 1; *Pediastrum*, 24; *Scenedesmus*, 8; *Staurastrum*, 144; *Zoöspores*, 1 Infusoria, *Dinobryon*, 35; *Peridinium*, 3; *Vorticella*, 6. Vermes, *Anurea*, 1; *Polyarthra*, 1; *Rotatorian ova*, 2; *Rotifer*, 2. Crustacea, *Cyclops*, .01. Miscellaneous, *Zoöglæa*, 80. Total, 707.

EXAMINATION OF RIVERS.

EXAMINATION OF RIVERS.

During the year 1893 regular monthly examinations were made of the waters of the Blackstone, Merrimack, Nashua (below Fitchburg), Neponset, Housatonic and Taunton rivers, and during the latter portion of the year, in connection with the investigations for a metropolitan water supply, of the Charles at South Natick, Deerfield, Nashua (above Clinton), and its tributaries, the Quinepoxet and Stillwater, Shawsheen and Ware rivers. A special examination has also been made of the tidal portion of the Charles River, which is a repetition of the examination of this stream made in 1893, and occasional examinations of other rivers in the State. Most of the results of these examinations will be found arranged alphabetically by rivers in the pages which follow; but some of them are given on preceding pages in connection with the examinations of water supplies, under the names of the towns where the samples were collected, as follows: —

	Page
Town River (a tributary of the Taunton) at Bridgewater,	125
Neponset River at Hyde Park,	177
Merrimack River at Lawrence,	181
Merrimack River at Lowell,	193
Taunton River at Taunton,	296

Blackstone River.

The character of the water of the Blackstone River is closely related to the disposal of the sewage of the city of Worcester, and it is therefore of interest to note that during 1893 the capacity of the precipitation works for treating the sewage of this city has been greatly increased by the construction of new precipitation tanks and other additions to the works, which were used for the first time on July 15. A full description of the works as originally constructed, and the results of a special examination of the works and the river during one week in 1891, can be found in the annual report of the State Board of Health for that year (pages 267–295).

through six-inch iron pipes to the sewer at a point ninety feet above the screens, instead of being discharged as formerly below the screens. This change was made in order to insure a more thorough mixing of the lime with the sewage previous to subsidence. The amount of lime necessary to make the sewage alkaline is determined by frequent tests with phenolphthalein.

The continuous process of precipitation is used, the sewage flowing through the different tanks in order, and the effluent being discharged continuously from the last one. The fall of the effluent is utilized, by means of a turbine wheel, to furnish power at night for lighting the works by electricity, and in the day time for pumping the sludge by means of a Shone ejector to sludge beds located near the Blackstone River. These beds at the present time cover an area of about fourteen acres. During 1893 nearly all of the sludge was disposed of to farmers for use as a fertilizer.

During the year ending Nov. 30, 1893, 1,795,000,000 gallons of sewage were treated and 1,105 tons of lime were used, making the amount of lime 1,232 pounds per million gallons of sewage. The amount of solid matter removed from the water during the year amounted to 2,360 tons.

The Worcester precipitation works have always been very intelligently operated under the direction of skilled chemists and engineers, and the following quotations from the annual report of the superintendent of sewers for the year ending Nov. 30, 1893, will be of interest as indicating the manner in which the work is carried on and the results obtained in the treatment of sewage since the works have been enlarged.

"From the first day the plant was operated, June 25, 1890, continued experiments have been made; at first, these were wholly mechanical and at random, but it was soon found that a systematic study of the whole problem must be made if the work was to be successful. Accordingly a well-equipped chemical laboratory has been provided and the problems met in actual manipulation are made subjects for special investigation. That this move has been productive of good is shown by the reduction of from thirty to fifty per cent. in the cost of chemicals used per million gallons of sewage treated.

Analyses of sewage and effluent are made daily. The samples for analysis are each composed of twenty-four portions taken hourly. Thus, by averaging results for several days, an effluent is obtained corresponding to

TABLE A.

WORCESTER SEWAGE PURIFICATION WORKS.*

Analyses of Sewage and Effluent.

[Parts per 100,000.]

DATE OF COLLECTION.	Residue on Evaporation.									Ammonia.				Oxygen Consumed.		
	Total Residue.			Volatile Residue.			Fixed Residue.				Albuminoid.					
	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	Chlorine.
Sewage, July 19-31, 1893,	70.2	48.0	22.2	32.1	17.9	14.2	38.1	30.1	8.0	1.043	.622	.403	.219	5.62	3.18	6.64
Effluent, July 19-31, 1893,	59.2	56.0	3.2	16.0	13.5	2.5	43.2	42.5	0.7	.973	.356	.239	.117	3.29	2.56	6.44
Per cent. removed,	15.67	16.67	85.59	50.16	24.59	82.39	13.39	41.20	91.23	6.71	42.78	40.69	46.58	41.47	19.50	2.99
Sewage, August, 1893,	61.2	40.9	20.3	30.7	18.6	12.1	30.5	22.3	8.2	1.137	.558	.258	.300	5.90	3.24	6.49
Effluent, August, 1893,	53.9	50.7	3.2	14.9	13.5	1.4	39.0	37.2	1.8	1.083	.333	.264	.069	3.70	3.42	6.49
Per cent. removed,	11.92	19.33	84.24	51.47	27.42	88.43	27.87	66.82	78.05	4.75	40.33	2.32	77.00	37.28	5.56	0.00
Sewage, September, 1893,	62.1	43.4	18.7	29.3	17.0	12.3	32.8	26.4	6.4	1.488	.522	.247	.275	5.11	3.15	6.16
Effluent, September, 1893,	54.0	51.7	2.3	14.6	13.5	1.1	39.4	38.2	1.2	1.426	.250	.204	.046	3.33	3.03	6.01
Per cent. removed,	13.04	19.13	87.70	50.17	20.59	91.05	20.12	44.70	81.25	4.17	52.11	17.42	83.28	34.83	3.81	2.43
Sewage, October, 1893,	67.7	46.4	21.3	28.7	16.6	12.1	39.0	29.8	9.2	1.584	.576	.279	.297	4.96	2.69	5.57
Effluent, October, 1893,	54.0	51.6	2.4	13.3	12.5	0.8	40.7	39.1	1.6	1.504	.288	.214	.074	3.37	3.13	6.31
Per cent. removed,	20.21	11.20	88.74	53.65	24.70	93.40	4.36	31.21	82.60	5.05	50.00	33.30	75.08	32.06	16.36	13.30
Sewage, November, 1893,	57.5	41.7	15.8	22.8	13.1	9.7	34.6	28.6	6.0	1.546	.450	.220	.230	4.49	2.14	5.69
Effluent, November, 1893,	51.4	50.0	1.4	12.1	11.5	0.6	39.3	38.5	0.8	1.465	.196	.155	.041	3.49	3.30	5.97
Per cent. removed,	10.69	19.91	91.11	46.93	12.21	93.80	13.58	34.61	86.67	5.36	56.44	29.54	82.19	22.27	54.20	4.92

Averages of Analyses July 19 to Dec. 1, 1893.

DATE OF COLLECTION.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	Chlorine.
Sewage,	62.8	43.5	19.3	28.3	16.5	11.8	34.5	27.0	7.5	1.395	.536	.266	.270	5.17	2.85	6.05
Effluent,	53.9	51.5	2.4	13.9	12.8	1.1	40.0	38.7	1.3	1.325	.276	.213	.063	3.43	3.15	6.23
Per cent. removed,	14.18	18.40	87.56	50.88	22.43	90.67	15.94	43.33	82.6	5.01	48.49	19.88	76.67	33.65	10.53	2.98

* This table of analyses made at the Worcester Sewage Purification Works is taken from the annual report of the superintendent of sewers of Worcester for the year ending Nov. 30, 1893.

BLACKSTONE RIVER.

AVERAGES OF CHEMICAL ANALYSES OF WATER FROM THE BLACKSTONE RIVER FOR SIX MONTHS FROM JUNE TO NOVEMBER, INCLUSIVE, OF EACH YEAR FROM 1887 TO 1893.

Blackstone River between Mill Brook Channel and the Sewage Precipitation Works.

[Parts per 100,000.]

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	1.14	9.92	3.03	.2107	.1246	.0673	.0573	1.07	.0250	.0015	2.9
" " 1891,	1.10	17.42	5.59	.4913	.1950	.1127	.0823	2.29	.0192	.0037	5.0
" " 1892,	0.52	20.75	6.30	.3547	.1433	.0708	.0725	2.43	.0227	.0108	6.1
" " 1893,	0.40	16.98	4.55	.1480	.0588	.0240	.0348	1.01	.0115	.0015	6.3

Blackstone River below Sewage Precipitation Works.

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov, 1887,	0.91	-	-	.2686	.1741	-	-	1.35	.0160	-	-
" " 1888,	0.76	-	-	.2658	.1112	.0557	.0555	1.50	.0382	.0041	-
" " 1889,	0.86	-	-	.3980	.1430	.0772	.0658	1.32	.0177	.0026	-
" " 1890,	0.97	11.36	3.10	.2907	.1492	.0722	.0770	1.46	.0270	.0018	3.9
" " 1891,	1.05	22.25	6.60	.6367	.1508	.0883	.0625	2.61	.0233	.0040	6.2
" " 1892,	0.63	26.80	7.75	.5240	.1810	.0958	.0852	3.13	.0137	.0050	10.3
" " 1893,	0.51	30.00	7.18	.5680	.1453	.0900	.0553	2.76	.0285	.0126	10.9

Blackstone River at Uxbridge.

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887,	0.39	-	-	.1129	.0271	-	-	0.79	.0360	-	-
" " 1888,	0.38	6.42	1.52	.1155	.0288	.0222	.0066	0.68	.0310	.0007	-
" " 1889,	0.32	-	-	.1133	.0296	.0192	.0104	0.66	.0333	.0009	-
" " 1890,	0.26	8.86	2.12	.1629	.0231	.0174	.0057	0.79	.0259	.0005	2.9
" " 1891,	0.20	10.16	2.61	.2280	.0175	.0117	.0058	1.04	.0425	.0007	3.6
" " 1892,	0.13	9.36	1.58	.2840	.0227	.0162	.0065	0.99	.0313	.0007	3.1
" " 1893,	0.24	11.74	2.37	.1985	.0207	.0140	.0067	1.20	.0623	.0050	4.2

Blackstone River at Millville.

MONTHS.	Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
June-Nov., 1887,	0.31	-	-	.0468	.0220	-	-	0.51	.0210	-	-
" " 1888,	0.41	5.22	1.40	.0467	.0296	.0233	.0063	0.50	.0278	.0004	-
" " 1889,	0.38	-	-	.0499	.0273	.0213	.0060	0.45	.0167	.0003	-
" " 1890,	0.26	6.71	2.24	.0736	.0196	.0152	.0044	0.53	.0229	.0003	2.3
" " 1891,	0.24	7.48	2.35	.1105	.0384	.0234	.0150	0.72	.0308	.0006	2.2
" " 1892,	0.37	6.70	1.62	.1143	.0294	.0210	.0084	0.63	.0217	.0002	2.0
" " 1893,	0.23	7.43	1.73	.0677	.0119	.0087	.0031	0.77	.0385	.0011	2.6

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River between

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dis-solved.	Total Residue. Sus-pended.	Loss on Ignition. Total.	Loss on Ignition. Dis-solved.	Loss on Ignition. Sus-pended.
		1893.									
1	9926	Jan. 24	Decided.	Heavy, brown.	0.90	28.60	22.50	6.10	9.90	6.10	3.80
2	10013	Feb. 14	Decided.	Heavy, gray.	0.50	16.20	11.20	5.00	5.80	4.00	1.80
3	10123	Mar. 14	Thick.	Cons., gray.	0.40	37.80	6.60	31.20	5.50	1.60	3.90
4	10263	April 18	Decided, milky.	Heavy, yellow.	1.40	12.50	9.00	3.50	5.30	3.30	2.00
5	10413	May 17	Decided, milky.	Heavy, gray.	1.30	9.80	6.20	3.60	2.50	1.40	1.10
6	10538	June 20	Decided.	Heavy, brown.	0.30	22.70	15.10	7.60	8.50	3.70	4.80
7	10676	July 18	Decided.	Heavy, brown.	1.80	18.50	-	-	5.60	-	-
8	10870	Aug. 22	Distinct, milky.	Heavy, iron.	0.10	10.60	-	-	1.00	-	-
9	11052	Sept. 19	Decided, milky.	Cons., rusty.	0.15	15.80	10.80	5.00	4.40	2.80	1.60
10	11212	Oct. 17	Decided.	Cons., rusty.	0.08	16.10	15.10	1.00	3.60	3.30	0.30
11	11369	Nov. 21	Decided.	Cons.	0.04	18.20	17.20	1.00	4.20	4.00	0.20
12	11524	Dec. 19	Distinct.	Slight, dark.	1.20	8.60	7.90	0.70	2.30	2.30	0.00
13	Av..	....	....	....	0.68	17.95	-	-	4.88	-	-

Odor, offensive.——The samples were collected from the river about 200 feet below the iron bridge. No. 10413 was collected on Wednesday and the remaining samples on Thursday. The first sample was collected at 12.45 P.M., and the remaining samples between 2.00 and 3.55 P.M.

Chemical Examination of Water from Blackstone

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dis-solved.	Total Residue. Sus-pended.	Loss on Ignition. Total.	Loss on Ignition. Dis-solved.	Loss on Ignition. Sus-pended.
		1893.									
1	9927	Jan. 24	Decided.	Heavy, brown.	0.65	33.80	26.50	7.30	11.20	7.10	4.10
2	10014	Feb. 14	Decided.	Heavy, gray.	0.70	16.40	13.80	2.60	6.00	4.00	2.00
3	10124	Mar. 14	Thick.	Cons., gray.	0.50	38.30	6.80	31.50	7.20	1.80	5.40
4	10264	April 18	Decided, milky.	Heavy, yellow.	1.40	13.70	9.20	4.50	5.50	3.00	2.50
5	10414	May 17	Decided, milky.	Heavy, gray.	1.40	10.00	6.00	4.00	2.10	1.50	0.60
6	10539	June 20	Decided.	Heavy.	1.00	24.00	14.60	9.40	9.40	3.70	5.70
7	10677	July 18	Decided.	Heavy, brown.	1.00	30.90	-	-	5.70	-	-
8	10871	Aug. 22	Decided, milky.	Cons., dark.	0.40	16.60	-	-	3.80	-	-
9	11053	Sept. 19	Thick, milky.	Heavy, rusty.	0.40	34.80	29.00	5.80	8.60	6.80	1.80
10	11213	Oct. 17	Distinct.	Cons., rusty.	0.18	44.50	43.50	1.00	8.90	8.30	0.60
11	11370	Nov. 21	Decided.	Heavy, rusty.	0.10	29.20	24.80	4.40	6.40	5.00	1.40
12	11525	Dec. 19	Distinct.	Slight, rusty.	1.10	15.60	12.80	2.80	3.70	3.50	0.20
13	Av..	....	....	....	0.74	25.65	-	-	6.54	-	-

Odor, offensive.——The samples were collected from the river above Millbury and below the point where the effluent from the Worcester Precipitation Works enters the river. No. 10414 was collected on Wednesday and the remaining samples on Thursday. The samples were collected between 1.00 and 3.10 P.M.

BLACKSTONE RIVER.

Mill Brook Channel and the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Iron		Hardness.	
	Albuminoid.									
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.		
.3840	.2820	.1960	.0860	2.28	.0070	.0007	4.4000	3.4000	7.0	1
.2030	.1260	.0820	.0440	1.34	.0300	.0011	.3440	.2200	1.4	2
.0800	.0820	.0540	.0280	1.00	.0200	.0012	.5400	.1300	1.9	3
.0510	.0580	.0330	.0250	.74	.0250	.0020	.3000	.2400	2.2	4
.0520	.0400	.0280	.0120	.33	.0400	.0007	.0340	.0200	1.5	5
.2800	.2040	.0600	.1440	2.16	.0300	.0050	1.7000	.7400	5.1	6
.0800	.0450	.0240	.0210	.76	.0000	.0000	4.6000	-	9.7	7
.0660	.0240	.0130	.0110	.79	.0300	.0012	.6000	-	3.9	8
.2560	.0540	.0320	.0220	.90	.0090	.0014	.8000	.1000	3.7	9
.1680	.0110	.0090	.0020	.85	.0000	.0009	3.1000	1.0400	6.0	10
.0480	.0150	.0060	.0090	.60	.0000	.0005	1.3200	.9400	9.6	11
.0520	.0360	.0300	.0060	.70	.0250	.0003	.3500	.1800	1.9	12
.1429	.0814	.0472	.0342	1.04	.0180	.0012	1.5073	.5842	4.5	13

Microscopical Examination.

Nos. 10123 and 10268 were not examined. The remaining samples contained Zoöglœa, generally in very large numbers, and only a few of other organisms.

River below the Worcester Sewage Precipitation Works.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Iron.		Hardness.	
	Albuminoid.									
Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.		
.4960	.4600	.2420	.2180	2.40	.0070	.0009	4.9000	3.6000	10.1	1
.2160	.1400	.0820	.0580	1.60	.0400	.0015	.4700	.3000	3.5	2
.0850	.1020	.0560	.0460	0.96	.0220	.0010	.5200	.1240	2.5	3
.0450	.0480	.0300	.0180	0.77	.1000	.0020	.7000	.2000	1.8	4
.0560	.0480	.0280	.0200	0.34	.0400	.0007	.0390	.0200	1.5	5
.2960	.2640	.0940	.1700	2.52	.0070	.0001	1.3500	.4400	3.6	6
.2600	.0620	.0290	.0330	2.17	.0000	.0000	3.9000	-	16.6	7
.2320	.0780	.0390	.0390	1.54	.0150	.0100	.0500	-	5.7	8
.9600	.2200	.1600	.0600	3.84	.0050	.0512	.7600	.1500	11.9	9
.9600	.1670	.1590	.0080	4.44	.0750	.0035	.2950	.0100	16.1	10
.7000	.0810	.0590	.0220	2.02	.0690	.0060	.6000	.0080	11.2	11
.2000	.0670	0590	.0080	1.15	.0630	.0018	.3800	.2800	4.6	12
.3757	.1447	.0864	.0583	1.98	.0369	.0070	1.1637	.5132	7.4	13

Microscopical Examination.

Nos. 10124 and 10264 were not examined. The remaining samples contained Zoöglœa often in very large numbers, and only a few of other organisms.

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Uxbridge.

[Parts per 100,000.]

Iron, .0474. Odor, generally musty, occasionally disagreeable or offensive.—— The samples were collected from the canal leading from the upper dam of the Calumet Woolen Company to the mill just before the water passed the screens.

Microscopical Examination.

The number of organisms found in these samples varied from 148 to 8,360 per cubic centimeter and averaged 787, Zoöglœa being by far the most abundant and averaging 724.

BLACKSTONE RIVER.

Chemical Examination of Water from Blackstone River at Millville, Blackstone.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
9906	Jan. 19	Slight, milky.	Slight.	0.50	6.05	1.40	.0594	.0280	.0246	.0034	.43	.0280	.0003	.3869	1.9
10031	Feb. 16	Distinct, clayey.	Slight, earthy.	0.60	4.20	1.40	.0400	.0180	.0150	.0030	.33	.0180	.0001	.4710	1.1
10134	Mar. 16	Distinct, milky.	Cons., gray.	0.50	3.35	1.05	.0250	.0130	.0050	.0080	1.04	.0100	.0004	.3996	0.9
10283	Apr. 20	Distinct, milky.	Slight.	0.65	4.30	1.15	.2200	.0920	.0720	.0200	.36	.0200	.0005	.3869	1.1
10419	May 18	Distinct, milky.	Cons., rusty.	0.65	4.60	1.70	.1920	.0930	.0760	.0170	.30	.0150	.0005	.4124	1.1
10558	June 23	Distinct, milky.	Slight.	0.35	5.10	1.45	.0760	.0100	.0050	.0050	.46	.0050	.0003	.2765	1.5
10689	July 20	Distinct, milky.	Cons.	0.05	7.55	1.50	.1930	.0170	.0140	.0030	.88	.0200	.0002	.1924	2.5
10887	Aug. 24	Slight.	Slight, rusty.	0.28	8.70	2.70	.0174	.0044	.0032	.0012	.97	.0500	.0010	.3531	2.6
11074	Sept. 21	Slight.	Cons., brown.	0.18	8.75	1.95	.0160	.0228	.0192	.0036	.88	.0700	.0028	.3239	3.1
11230	Oct. 19	Distinct, milky.	Slight.	0.20	8.35	1.65	.0280	.0100	.0070	.0030	.82	.0580	.0017	.3230	3.0
11381	Nov. 23	Distinct.	Slight.	0.30	6.10	1.15	.0760	.0070	.0040	.0030	.60	.0280	.0006	.1512	2.6
11538	Dec. 21	Distinct, milky.	Slight.	0.50	7.70	1.30	.1360	.0300	.0250	.0050	.83	.0250	.0007	.5265	2.3
Av.	....	....	....	0.40	6.23	1.53	.0899	.0288	.0225	.0063	0.66	.0289	.0008	.3503	2.0

Iron, .0452. Odor, generally musty, frequently disagreeable or offensive. —— The samples were collected from the river just above the dam in the village of Millville.

Microscopical Examination.

The number of organisms found in these samples varied from 107 to 946 per cubic centimeter and averaged 294, Zoöglœa being in most cases by far the most abundant and averaging 224.

Charles River.

Regular monthly examinations of the water of Charles River above South Natick have been made during the last five months of 1893, and weekly examinations of the water at Ætna Mills and at a point about 2,000 feet below Galen Street bridge in Watertown were made from August 17 to October 26. An examination of the whole length of the tidal portion of the river by means of a series of chemical analyses of its water at high and low tide was made on August 17, 1893, during a course of neap tides occurring at a time when the flow of upland water was small. This examination of the tidal portion of the river is a repetition of a similar examination made in 1892, and fully described in the annual report of the State Board of Health for that year (pp. 282–289). Results of all of the analyses made during 1893 are given in the following tables: —

CHARLES RIVER.

Microscopical Examination of Water from the Charles River at Ætna Mills, Waterlown.

[Number of organisms per cubic centimeter.]

	1893.											
	Aug.	Aug.	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct	Oct.
Day of examination,	-	-	29	2	9	16	23	2	7	16	21	27
Number of sample,	10620	10849	10892	10949	10992	11028	11078	11119	11151	11197	11231	11254
PLANTS.												
Diatomaceæ,	-	-	1	7	6	1	3	0	10	6	4	9
Asterionella,	-	-	0	0	0	0	0	0	0	5	0	2
Cyclotella,	-	-	0	0	5	0	0	0	0	0	1	2
Navicula,	-	-	1	2	0	0	0	0	0	0	1	4
Synedra,	-	-	0	5	1	1	3	0	2	1	1	1
Tabellaria,	-	-	0	0	0	0	0	0	8	0	1	0
Algæ, Protococcus,	-	-	20	4	0	0	0	0	0	0	0	0
Fungi,	-	-	200	200	36	1,400	108	249	92	120	36	11
Crenothrix,	-	-	200	200	36	1,400	108	249	92	120	30	11
Molds,	-	-	0	0	0	0	0	0	0	0	6	0
ANIMALS.												
Infusoria,	-	-	3	1	0	1	0	0	0	3	0	1
Monas,	-	-	0	1	0	0	0	0	0	2	0	1
Peridinium,	-	-	0	0	0	1	0	0	0	1	0	0
Trachelomonas,	-	-	3	0	0	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	-	-	204	76	36	40	24	48	140	48	10	48
TOTAL,	-	-	428	288	78	1,442	135	297	242	177	50	69

CHARLES RIVER.

Chemical Examination of Water from Charles River about Two Thousand Feet below Galen Street Bridge, Waterlown.

[Parts per 100,000.]

Number.		Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1898.														
10821	Aug 17	Distinct.	Cons., floc'nt.	0.75	-	-	.0024	.0320	.0266	.0054	0.87	[illegible]	.0002	1.0191	-
10850	Aug.17	Distinct.	Cons., fibrous.	0.70	-	-	.0006	.0328	.0278	.0050	1.53	.0200	.0004	.7488	-
10893	Aug.25	Slight.	Cons., brown.	0.70	7.20	2.15	.0052	.0284	.0226	.0058	0.73	.0200	.0008	.6478	2.2
10950	Aug.31	Distinct.	Cons, brown.	[illegible]	6.80	2.60	.0048	.0246	.0212	.0034	0.94	.0150	.0004	.5451	1.9
10993	Sept. 7	Slight.	Slight.	0.90	7.70	3.10	.0006	.0274	.0226	.0048	0.68	.0250	.0009	.6240	2.5
11029	Sept.14	Distinct.	Cons., dark.	0.68	13.00	4.05	.0006	.0414	.0274	.0140	1.80	.0120	.0009	.6436	4.1
11079	Sept.21	Distinct.	Cons., fibrous.	0.60	8.15	2.40	.0000	.0304	.0258	.0046	0.80	.0100	.0005	.6970	3.1
11120	Sept.29	V. slight.	Heavy, gray.	0.63	8.40	2.20	.0020	.0228	.0204	.0024	1.66	.0200	.0003	.4851	2.6
11152	Oct. 5	Decided	Heavy, gray.	0.45	9.60	2.40	.0000	.0392	.0224	.0168	1.19	.0150	.0007	.5775	2.4
11198	Oct. 13	Decided.	Cons., gray.	0.55	13.30	3.25	.0016	.0378	.0236	.0142	2.81	.0100	.0007	.7533	4.7
11232	Oct. 19	Distinct.	Cons.	0.55	12.10	2.00	.0042	.0364	.0276	.0088	1.96	.0300	.0013	.8056	4.2
11255	Oct. 26	Slight.	Cons., gray.	0.45	12.70	2.10	[illegible]	.0330	.0240	.0090	2.46	.0290	.0018	.8396	3.6
Av..	....	....	....	0.63	9.89	2.68	.0024	.0322	.0243	.0079	1.46	.0180	.0007	.6730	3.2

Iron, .0318. Odor, decidedly vegetable and musty or mouldy. —— The samples were collected from the river about 2,000 feet below Galen Street bridge in Watertown, and about 400 feet below Barker's Starch Works. The point at which the samples were collected is in the tidal portion of the river, but it is doubtful if any salt water ever flows up to this point.

Microscopical Examination of Water from Charles River about Two Thousand Feet below Galen Street Bridge, Waterlown.

[Number of organisms per cubic centimeter.]

	1898.											
	Aug.	Aug.	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct.	Oct.
Day of examination, . .	-	-	29	2	9	16	22	2	7	16	21	27
Number of sample, . .	10821	10850	10893	10950	10993	11029	11079	11120	11152	11198	11232	11255
PLANTS.												
Diatomaceæ, . .	-	-	0	7	3	9	3	0	8	0	8	25
Navicula, . . .	-	-	0	2	1	1	0	0	0	0	2	1
Synedra, . . .	-	-	0	5	2	8	3	0	8	0	6	24
Cyanophyceæ, Oscillaria, ...	-	-	1	0	0	20	1	[illegible]	0	0	0	0
Algæ, Chlorococcus, .	-	-	0	0	0	0	0	0	1	4	0	0

CHARLES RIVER.

Microscopical Examination of Water from Charles River, etc. — Concluded.

[Number of organisms per cubic centimeter.]

	1893.											
	Aug.	Aug.	Aug.	Sept.	Sept.	Sept.	Sept.	Oct.	Oct.	Oct.	Oct.	Oct.
PLANTS — Con.												
Fungi,	-	-	**44**	**132**	**180**	**82**	**4**	**116**	**172**	**50**	**27**	**128**
Beggiatoa,	-	-	0	0	0	2	0	0	0	0	1	32
Crenothrix,	-	-	44	132	180	80	4	118	172	50	26	96
ANIMALS.												
Infusoria,	-	-	**0**	**4**	**3**	**1**	**3**	**0**	**3**	**6**	**1**	**1**
Monas,	-	-	0	0	1	1	3	0	0	4	0	1
Paramæcium,	-	-	0	0	0	0	0	0	3	2	0	0
Peridinium,	-	-	0	4	0	0	0	0	0	0	1	0
Trachelomonas,	-	-	0	0	2	0	0	0	0	0	0	0
Miscellaneous, Zoöglœa,	-	-	**108**	**104**	**56**	**84**	**400**	**152**	**192**	**808**	**260**	**440**
TOTAL,	-	-	153	255	242	176	411	274	376	868	296	603

Chemical Examination of Water from the Tidal Portion of Charles River at Various Points, during High Water of Neap Tides, Aug. 17, 1893.

[Parts per 100,000.]

Number.	LOCALITY.	APPEARANCE.			ODOR.		AMMONIA.				Chlorine.	Nitrogen as Nitrites.	Oxygen Consumed.
								Albuminoid.					
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Free.	Total.	Dissolved.	Suspended.			
10851	Beachwood Avenue.	Distinct.	Cons., fibrous.	0.65	Decided, musty.	Distinct, musty.	.0120	.0336	.0270	.0066	37.18	.0008	.7521
10852	Opposite Islands.	Distinct.	Slight, earthy.	0.50	Decided, fishy.	Decided, clam	.0520	.1104	.0392	.0712	412.1	.0025	1.3335
10853	No. Beacon Street.	Slight.	Cons., rusty.	0.30	Distinct, fishy.	Faintly fishy	.0784	.0688	.0286	.0402	774.0	.0034	1.5800
10854	Western Avenue.	Slight.	Slight, rusty.	0.18	Distinct.	V. faintly fishy.	.0672	.0544	.0160	.0384	1156.5	.0030	2.1804
10855	Cambridge Cemetery.	Slight.	Slight, rusty.	0.20	Distinct.	Faintly clam.	.0720	.0408	.0216	.0192	1050.0	.0028	2.1804
10856	No. Harvard Street.	Slight.	Slight.	0.12	Faint.	Faintly musty.	.0776	.0270	.0196	.0074	1472.5	.0038	2.4427
10857	Cambridge Street.	V. slight.	Slight.	0.09	Faint.	Faintly musty.	.0760	.0460	.0198	.0262	1485.0	.0027	2.4866
10858	Essex St.,	V. slight.	Slight.	0.10	Faint.	Decided, dis'g'ble.	.0840	.0330	.0200	.0130	1476.0	.0026	2.9952
10859	Harvard Bridge.	V. slight.	Slight.	0.08	V. faint or none.	Faint.	.0696	.0296	.0170	.0126	1630.0	.0027	2.8392
10860	W. Boston Bridge.	V. slight.	V. slight.	0.04	None.	V. faint or none.	.0320	.0154	.0128	.0026	1725.0	.0015	2.9016
10861	Craigie's Bridge.	V. slight.	V. slight.	0.04	None.	None.	.0232	.0138	.0092	.0046	1737.0	.0012	3.1574
10862	Charles Riv. Bridge.	V. slight.	V. slight.	0.01	Faint, musty.	Faint.	.0224	.0114	.0096	.0018	1747.0	.0007	3.6192

Housatonic River.

Regular monthly examinations of the water of this river were made from March to the end of the year with a view to determining the extent to which the river is polluted by the sewage of the city of Pittsfield and other places upon its watershed. The samples were collected at New Lenox, which is distant about 3.9 miles by the river below the place where the sewage of Pittsfield is discharged into the stream. The drainage area of the river at New Lenox is 145.6 square miles, and the population on this area, by the census of 1890, was 23,300, equivalent to a population of 160 per square mile. Of the total population, 17,281 were in the city of Pittsfield.

Chemical Examination of Water from the Housatonic River at New Lenox.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1892.														
10167	Mar. 27	Distinct, clayey.	Cons., earthy.	0.25	5.65	1.60	.0044	.0190	.0142	.0048	.10	.0200	.0002	.3504	8.5
10324	Apr. 27	Slight.	Cons.	0.15	7.80	2.05	.0052	.0114	.0098	.0016	.20	.0180	.0001	.3467	5.6
10462	May 31	Slight.	Cons.	0.20	10.25	2.25	.0022	.0122	.0098	.0024	.16	.0200	.0002	.3000	7.6
10573	June 29	Distinct.	Slight.	0.20	10.55	2.15	.0080	.0196	.0142	.0054	.21	.0200	.0005	.4305	7.7
10709	July 26	Distinct, milky.	Cons., dark.	0.20	12.40	2.70	.0078	.0238	.0172	.0066	.18	.0120	.0020	.2960	8.1
10897	Aug. 28	Slight.	Slight.	0.55	11.60	3.10	.0162	.0202	.0172	.0030	.19	.0230	.0067	.7189	8.3
11068	Sept. 20	Slight.	Slight.	0.40	11.10	2.70	.0060	.0186	.0166	.0020	.14	.0120	.0030	.4346	8.6
11221	Oct. 17	Slight.	Slight.	0.55	11.15	2.55	.0056	.0206	.0162	.0044	.17	.0100	.0004	.5282	7.7
11384	Nov. 23	Distinct.	Cons.	0.23	10.25	1.45	.0008	.0126	.0092	.0084	.19	.0200	.0004	.4242	8.1
11555	Dec. 26	Decided.	Heavy.	0.25	6.50	1.55	.0014	.0162	.0094	.0068	.10	.0200	.0001	.3503	4.3
Av.	....	....	....	0.30	9.73	2.21	.0058	.0174	.0134	.0040	.16	.0175	.0014	.4180	7.0

Iron, .0140. Odor, generally decidedly mouldy or musty, rarely none. —— The samples were collected from the river.

HOUSA

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Day of ex	
Number o	
Diatom	
Aster	
Fragil	
Meloe	
Navic	
Syned	
Algæ, .	
Proto	
Zoösp	
Fungi,	
Creno	
Molds	
Rhizop	
Infusor	
Ciliate	
Dinob	
Eugle	
Monas	
Param	
Peridi	
Tintin	
Miscellan	
TOTAL	

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table :-

MERRIMACK RIVER.

Table comparing the Analyses above Lowell with those above Lawrence, 1893.

[Parts per 100,000.]

	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Number of determinations compared, ...	12	12	12	12	12	12	12	12	12	12	12
Mean of analyses above Lowell,	0.33	3.39	1.18	.0026	.0149	.0120	.0029	.167	.0083	.0001	1.1
Mean of analyses above Lawrence, ...	0.42	3.86	1.48	.0057	.0181	.0141	.0040	.202	.0081	.0002	1.1
Increase, ...	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002*	.0001	0.0

In order to compare these results with similar ones obtained in previous years, another table is presented, which contains the increase in impurities as the water passes from a point above Lowell to Lawrence, as given in the last line of the above table, and the corresponding increase in previous years: —

Increase in the Amount of Impurities in the Merrimack River Water, from a Point above Lowell to Lawrence, as determined by the Regular Monthly Examinations of Different Years.

[Parts per 100,000.]

DATE.	Color.	Residue on Evaporation: Total.	Residue on Evaporation: Loss on Ignition.	Ammonia: Free.	Ammonia: Albuminoid: Total.	Ammonia: Albuminoid: Dissolved.	Ammonia: Albuminoid: Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Hardness.
Increase, 1887-1889, .	0.01	0.23	0.09	.0007	.0027	.0017	.0009	.026	.0003*	.0000	-
Increase, 1890, . .	0.05	0.62	0.22*	.0016	.0023	.0017	.0006	.028	.0020*	.0000	0.2
Increase, 1891, . .	0.02*	0.29	0.07	.0021	.0023	.0021	.0002	.035	.0030*	.0000	0.1
Increase, 1892, . .	0.06	0.48	0.12	.0019	.0037	.0037	.0000	.039	.0013*	.0000	0.0
Increase, 1893, . .	0.09	0.47	0.30	.0031	.0032	.0021	.0011	.035	.0002*	.0001	0.0

The average flow of the river at Lawrence, per twenty-four hours, during the days on which samples were collected, was for the above periods, respectively, at the rate of 9,145, 9,948, 7,931, 5,433, and 8,126 cubic feet per second.

* Decrease.

NASHUA RIVER.

Nashua River.

Chemical Examination of Water from the North Branch of the Nashua River, below Fitchburg.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.									Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.									
	1898.														
9919	Jan. 23	Decided.	Cons., gray.	0.40	12.90	3.00	[illegible]							.1634	2.0
10049	Feb. 27	Decided.	Cons., gray.	0.40	8.70	1.80	[illegible]							.7632	2.6
10150	Mar. 20	Decided.	Cons., grey	0.33	8.90	1.55	[illegible]							.3852	1.3
10313	Apr. 25	Distinct, milky.	Cons., gray.	0.40	4.45	1.55	[illegible]							.5037	1.1
10436	May 23	Distinct.	Cons., floc'nt, fibrous.	0.60	4.15	1.60	[illegible]							.5662	0.8
10534	June 19	Decided, milky.	Heavy, brown.	0.60	7.25	1.85	[illegible]							.6293	1.0
10683	July 19	Distinct.	Cons.	0.50	8.75	2.10	[illegible]							.4894	2.5
10882	Aug. 23	Decided.	Heavy, brown.	1.00	10.90	3.30	[illegible]							.8027	2.3
11050	Sept. 19	Decided.	Cons.	0.70	6.50	2.35	[illegible]							.5922	1.0
11204	Oct. 16	Distinct.	Cons., gray.	0.80	7.90	2.40	[illegible]							.8100	2.5
11376	Nov. 23	Decided.	Heavy, gray.	0.60	8.60	2.80	[illegible]							.0626	2.1
11509	Dec. 18	Decided.	Cons., gray.	0.50	5.55	2.70	[illegible]							.5751	1.6
Av.	....	....	....	0.57	7.46	2.16	.0461	.0360	.0257	.0103	.00	.0118	.0018	.6927	2.0

Iron, .0357. Odor, musty or offensive. —— The samples were collected from the river about half a mile below the point where water from the tail-race of the Falulah Paper Company enters the stream.

Microscopical Examination of Water from the North Branch of the Nashua River, below Fitchburg.

[Number of organisms per cubic centimeter.]

	1898.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Day of examination,	25	28	23	26	24	21	21	25	20	17	24	20
Number of sample,	9919	10049	10150	10313	10436	10534	10683	10882	11050	11204	11376	11509
PLANTS.												
Diatomaceæ,	0	0	0	9	35	11	3	60	13	6	20	1
Asterionella,	0	0	0	1	4	0	0	0	0	0	0	1
Cyclotella,	0	0	0	pr.	0	1	1	20	0	0	0	0
Gomphonema,	0	0	0	0	0	0	0	[illegible]	0	0	0	0
Melosira,	0	0	0	0	8	0	0	10	13	0	0	0
Pinnularia,	0	0	0	0	0	0	0	10	0	0	0	0
Synedra,	0	0	0	7	20	8	2	10	0	0	2	0
Tabellaria,	0	0	0	1	3	2	0	0	0	6	18	0

NASHUA RIVER.

Microscopical Examination of Water from the North Branch of the Nashua River, below Fitchburg — Concluded.

[Number of organisms per cubic centimeter.]

	1893.											
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
PLANTS — Con.												
Cyanophyceæ,												
Oscillaria, ...	0	0	0	0	1	2	0	25	1	0	0	0
Algæ, Protococcus, .	0	0	0	0	0	0	0	0	52	0	0	0
Fungi, ...	0	38	0	8	168	13	2	45	160	54	14	7
Beggiatoa, ...	0	0	0	1	0	0	0	0	0	6	10	0
Crenothrix, . . .	0	38	0	0	168	13	2	45	160	48	4	7
Leptothrix, . . .	0	0	0	7	0	0	0	0	0	0	0	0
ANIMALS.												
Infusoria, ...	0	0	0	1	15	0	0	10	14	25	4	3
Dinobryon, . . .	0	0	0	0	7	0	0	0	12	24	0	0
Dinobryon cases, .	0	0	0	0	4	0	0	0	0	1	2	0
Euglena, ...	0	0	0	0	1	0	0	0	0	0	2	0
Monas, ...	0	0	0	1	3	0	0	5	0	0	0	2
Peridinium, . . .	0	0	0	0	0	0	0	0	2	0	0	1
Trachelomonas, . .	0	0	0	0	0	0	0	5	0	0	0	0
Miscellaneous, Zoöglœa, .	0	1,544	1,132	200	820	320	172	4,400	200	288	296	240
TOTAL, ...	*	1,582	1,132	218	1,039	346	177	4,540	440	373	334	251

* Amorphous matter very abundant.

Chemical Examination of Water from the South Branch of the Nashua River at Clinton.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
10763	Aug. 9	V. slight.	V. slight.	0.15	3.40	1.00	.0006	.0130	.0106	.0024	.26	.0030	.0001	.3436	1.0
10994	Sept. 8	V. slight.	Slight.	0.30	3.95	1.50	.0016	.0178	.0142	.0036	.26	.0000	.0002	.3666	1.8
11163	Oct. 10	V. slight.	Slight.	0.15	3.75	1.20	.0004	.0136	.0098	.0038	.30	.0000	.0000	.2233	1.7
11321	Nov. 10	V. slight.	V. slight.	0.80	4.90	1.90	.0000	.0164	.0134	.0030	.36	.0070	.0003	.7304	1.7
11452	Dec. 5	Slight.	V. slight.	0.65	3.95	1.50	.0006	.0184	.0164	.0020	.23	.0000	.0000	.6474	0.9
Av.	....	....	....	0.41	3.99	1.42	.0006	.0158	.0129	.0029	.28	.0020	.0001	.4623	1.4

Iron, .0064. Odor, vegetable. —— The samples were collected from the river above the dam of the Lancaster Manufacturing Company.

Microscopical Examination.

Average number of organisms, 97 per cubic centimeter.

NASHUA RIVER.

Chemical Examination of Water from the Quinepoxet River in Holden.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
10762	Aug. 9	Slight.	Slight.	0.60	3.40	1.65	.0002	.0188	.0148	.0040	.28	.0050	.0001	.5411	0.8
11015	Sept. 12	V. slight.	Slight.	0.45	3.55	1.50	.0004	.0162	.0132	.0030	.26	.0070	.0001	.3978	1.3
11153	Oct. 7	Slight.	Slight.	0.45	3.45	1.20	.0000	.0208	.0156	.0052	.20	.0030	.0000	.3927	0.6
11301	Nov. 7	V. slight.	Slight.	1.10	4.35	1.75	.0008	.0206	.0184	.0022	.32	.0030	.0002	1.0840	1.1
11446	Dec. 5	Distinct.	Cons.	1.00	4.00	1.75	.0004	.0194	.0178	.0016	.23	.0040	.0001	.8229	0.8
Av..	....	....	....	0.72	3.75	1.57	.0004	.0192	.0160	.0032	.26	.0044	.0001	.6477	0.9

Iron, .0126. Odor, vegetable. —— The samples were collected from the river at Smith's Woolen Mill in Holden, about one thousand feet from the line between Holden and West Boylston.

Microscopical Examination.

The average number of organisms, per cubic centimeter, found in these samples was 149; the greatest number present in any sample was 247, and the smallest number, 78.

Chemical Examination of Water from the Stillwater River in Sterling.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Sus-pended.		Nitrates.	Nitrites.		
	1893.														
10766	Aug. 9	V. slight.	Slight.	0.40	3.60	1.70	.0006	.0144	.0122	.0022	.14	.0000	.0000	.3713	0.6
11014	Sept. 12	V. slight.	V. slight.	0.60	3.40	1.40	.0004	.0154	.0132	.0022	.16	.0050	.0001	.4524	0.9
11154	Oct. 7	V. slight.	Slight.	0.20	2.95	0.90	.0008	.0120	.0106	.0014	.19	.0030	.0000	.2579	0.6
11300	Nov. 7	None.	Slight.	0.68	4.00	1.45	.0010	.0182	.0154	.0028	.26	.0030	.0001	.7480	1.1
11447	Dec. 5	V. slight.	V. slight.	0.62	3.30	1.45	.0000	.0136	.0116	.0020	.16	.0000	.0001	.6357	0.5
Av..	....	....	....	0.50	3.45	1.38	.0006	.0147	.0126	.0021	.18	.0022	.0001	.4931	0.7

Iron, .0088. Odor, of the first sample, none, becoming faintly vegetable on heating; of the remaining samples, distinctly vegetable, unchanged by heating. —— The samples were collected from the river at a highway bridge about one mile above the line between Sterling and West Boylston.

Microscopical Examination.

Average number of organisms, 119 per cubic centimeter.

QUINEBAUG RIVER.

Chemical Examination of Water from the Quinebaug River at Southbridge.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
11030	1893. Sept. 15	None.	Slight.	0.28	8.55	1.25	.0000	.0160	.0188	.0022	.24	.0030	.0001	.3822	1.1

Iron, .0230. Odor, none. —— The sample was collected from the river just above the Litchfield Spindle Company's dam at Shuttleville, at a time when the water in the river was very low. The dam at which the sample was collected is located about one and one-half miles above the main village of Southbridge.

Microscopical Examination.

Diatomaceæ, *Asterionella*, 2; *Navicula*, 5; *Synedra*, 4; *Tabellaria*, 1. Algæ, *Protococcus*, 12. Fungi, *Crenothrix*, 112. Miscellaneous, *Zoöglœa*, 11. Total, 147.

SHAWSHEEN RIVER.

Chemical Examination of Water from the Shawsheen River at Bedford.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
11309	1893. Nov. 8	V. slight.	Cons.	1.40	7.50	3.10	.0000	.0340	.0302	.0038	.58	.0000	.0000	1.4080	2.3
11310	Nov. 8	Slight.	Cons.	1.20	7.85	3.95	.0000	.0282	.0242	.0040	.60	.0070	.0003	1.5480	2.2

Iron in the first sample, .0130; in the second, .0110. Odor, distinctly vegetable and sweetish. —— The first sample was collected from the river above the point where it is joined by Vine Brook; the last sample from the river about a quarter of a mile below the mouth of Vine Brook. These samples were collected in the vicinity of the upper end of a proposed storage reservoir surveyed by the city of Boston in 1886.

Microscopical Examination.

The total number of organisms per cubic centimeter found in the first sample was 155, consisting chiefly of *Crenothrix* and *Zoöglœa*; in the last sample 839 organisms were found, nearly all of which were *Crenothrix*.

Stony Brook.

Chemical Examination of Water from Stony Brook at Inlet to the New Conduit at Roxbury.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1902.														
10621	July 10	Slight, milky.	Slight, dark.	0.30	16.25	4.60	.0384	.0302	.0242	.0060	1.99	.2200	.0120	.2628	7.1
10962	Sept. 5	Slight.	Slight, brown.	0.20	15.50	4.30	.0408	.0182	.0160	.0022	1.96	.2500	.0040	.2760	6.1

Iron, .0137. Odor of the first sample, decidedly vegetable and mouldy; of the last, faintly vegetable. —The samples were collected from the brook at the gate-house at the entrance to the new conduit at Roxbury.

Microscopical Examination.

No. 10621. Diatomaceæ, *Cyclotella*, 16; *Diatoma*, 24; *Navicula*, 4; *Stauroneis*, 2; *Synedra*, 1. Algæ, *Closterium*, 1; *Pediastrum*, 1; *Protococcus*, 2; *Scenedesmus*, 22; *Sorastrum*, 10; *Zoöspores*, 1. Fungi, *Crenothrix*, 82. Miscellaneous, *Zoöglœa*, 40. Total, 206.

No. 10962. Algæ, *Scenedesmus*, 1; Fungi, *Crenothrix*, 6; *Molds*, 8. Infusoria, *Peridinium*, 1. Miscellaneous, *Zoöglœa*, 24. Total, 40.

Taunton River.

Regular monthly examinations of the Taunton River above Taunton have been made as in previous years, and the results are printed in connection with analyses of water of the Taunton water supply on page 296. In the following table analyses are given of the water of Mill River, a tributary of the Taunton, near its mouth. The sewage of a portion of the city of Taunton is discharged into this river.

Chemical Examination of Water from the Mill River at Taunton.

[Parts per 100,000.]

Iron, .0625. Odor of the first sample, decidedly musty; of the second, decidedly vegetable, becoming unpleasant on heating; of the last sample, decidedly musty and disagreeable, becoming offensive on heating. — The samples were collected from the river at the Ingell Street bridge near its mouth.

SUMMARY

OF

WATER SUPPLY STATISTICS;

ALSO

RECORDS OF RAINFALL AND FLOW OF STREAMS.

SUMMARY OF WATER SUPPLY STATISTICS.

At the end of 1893 the State contained 30 cities and 322 towns. The towns of Medford and Everett became cities on Jan. 2, 1893, thus causing the change in the number of cities and towns since the previous year.

A public water supply was introduced during this year for the first time into the towns of Chester, North Brookfield and Provincetown, increasing the number of places supplied to 146. In addition to the new supplies for the places named above, new sources have been substituted for old ones in Attleborough, Chicopee, Easthampton, Orange and Taunton. In many other places additional works of less importance have been constructed to increase the capacity of the sources of supply.

It has been found by experience that there is unusual danger when water is taken directly from a running stream into which sewage is discharged, and it is therefore worthy of note that of the works constructed during the year those at Taunton, Chicopee and Orange were built for the purpose of abandoning the use of polluted streams as sources of supply, while at Lawrence, although the Merrimack River is still used as a source, the whole of the water used is filtered through a filter having an area of two and one-half acres to remove the disease germs which may be in the river water.

At Lowell new works for taking water from the ground have been constructed, which furnish a portion of the supply of the city, but the greater portion still comes from the Merrimack River.

The following table gives a classification, by population, of cities and towns having and not having public water supplies Dec. 31, 1893. The populations are taken from the census of 1890: —

Population (1890).	Number of Places of Given Population having a Public Water Supply.	Total Population of Places in Preceding Column.	Number of Places of Given Population not having a Public Water Supply.	Total Population of Places in Preceding Column.
Under 500,	0	0	28	9,772
500-1,000,	5	4,566	63	48,167
1,000-1,500,	6	7,249	43	52.810
1,500-2,000,	8	13,857	27	48,382
2,000-2,500,	9	19,987	14	30,299
2,500-3,000,	7	19,663	18	49,262
3,000-3,500,	8	26,010	5	15,899
3,500-4,000,	7	26,328	2	7,392
4,000-4,500,	11	47,201	5	21.367
Above 4,500,	85	1,779,952	1	6,138
Totals,	146	1,949,455	206	289,488

From the totals given in the table it will be seen that, although but forty-one per cent. of the cities and towns in the State have a public water supply, yet the total population of places supplied represents 87.1 per cent. of the whole population of the State. In this estimate of the total population of municipalities supplied all of the inhabitants in them are included, and it consequently includes rather more than the actual number of persons to whom a public water supply is available; the difference, however, is not large. There are now but 6 towns having, by the census of 1890, a population exceeding 4,000, which are not provided with a public water supply. These are given in the following table: —

Towns.	Population in 1890.	Towns.	Population in 1890.
Blackstone,	6,138	Winchendon,	4,390
Ipswich,*	4,439	Rockport,*	4,087
Millbury,	4,428	Barnstable,	4,023

* Works for the supply of Ipswich and Rockport were begun in 1894.

In the following table the various water supplies are classified according to the dates when a fairly complete system of supply was first introduced into a city or town: —

Years.	Number of Places Supplied.	Years.	Number of Places Supplied.
Previous to 1850,	6	1891,	5
1850-1859, inclusive,	4	1892,	1
1860-1869, inclusive,	10	1893,	3
1870-1879, inclusive,	44		
1880-1889, inclusive,	68	Total,	146
1890,	5		

Of the 30 cities in the Commonwealth, 28, having a total population in 1890 of 1,355,849, own their water works; while 2, having a total population of 38,598, are wholly supplied by private companies. Of the 116 towns having public water supplies, 69,* with a total population of 360,260, are supplied from their own works, while 47, with a total population of 194,748, are supplied by private companies. The total population in both cities and towns owning their works is 1,716,109, against 233,346 in those supplied by private companies.

The following table gives statistics with regard to the consumption of water in many of the cities and towns in this State. The populations for 1893, as given in the table, were obtained in a somewhat

* The figures in this paragraph differ somewhat from corresponding figures on page 5, owing to information received after the first figures were printed that the control of water works in two towns had passed from private companies to the public authorities.

arbitrary manner by adding three-fifths of the increase in population from 1885 to 1890 to the population as determined by the census taken in the latter year. The daily consumption per *inhabitant*, obtained by dividing the average daily consumption by the total population of the city or town in 1893, is less than the amount per *consumer*, because there are some in all cities and towns who do not use the public water supply. This difference between the number of inhabitants and consumers accounts, to a large extent, for the low rate, per inhabitant, in some towns where works have been in operation only a short time, and in consequence water has not been generally introduced; also, in towns where there are villages to which the public water supply has not been extended; but, after making all due allowance for the varying proportion of water takers, there is still a very great difference in the amount of water used per person in different places, which it is very difficult to account for.

Statistics relating to the Consumption of Water in Various Cities and Towns.

City or Town.	Population. 1893.	Average Daily Consumption. Gallons. 1893.	Daily Consumption per Inhabitant. Gallons.
Abington and Rockland,	10,067	312,000	31
Andover,	6,400	285,000	45
Attleborough,*	8,036	218,000	27
Avon,	1,619	55,000	34
Ayer,	2,124	71,000	33
Beverly,	11,802	843,000	71
Boston (Cochituate Works),	444,575	47,446,000	107
Boston, Somerville, Chelsea, and Everett (Mystic Works),	128,458	11,162,000	87
Braintree,	5,334	290,000	54
Bridgewater and East Bridgewater,	7,472	146,000	19
Brockton,	31,200	698,000	22
Brookline,	13,647	1,216,000	89
Cambridge,	76,250	6,123,000	80
Canton,	4,634	186,000	40
Cohasset,	2,486	56,000	22
Cottage City,	1,302	58,000	45
Danvers and Middleton,	8,630	571,000	66
Dedham,	[illegible]112	308,000	41
Easton,	[illegible]20	92,000	19
Fall River,	[illegible]16	2,334,000	27
Foxborough,	[illegible]05	81,000	27
Framingham,	[illegible]18	282,000	29
Franklin,	[illegible]41	126,000	24
Gardner,	[illegible]08	641,000	70
Gloucester,	[illegible]21	774,000	29
Hyde Park,	[illegible]81	499,000	44
Lawrence,	[illegible]28	3,153,000	68
Lowell,	[illegible]60	5,817,000	79
Lynn and Saugus,†	[illegible]58	3,744,000	64
Malden,	[illegible]06	1,451,000	64

City or Town.	Population. 1893.	Average Daily Consumption. Gallons. 1893.	Daily Consumption per Inhabitant. Gallons.
Manchester,	1,879	101,000	54
Mansfield,	3,729	209,000	56
Marblehead,	8,613	191,000	22
Marlborough,	15,524	440,000	28
Medford,	[illegible]00	611,000	50
Melrose,	[illegible]71	652,000	66
Middleborough,	[illegible]05	197,000	30
Milton,	[illegible]18	129,000	27
Montague,	[illegible]95	323,000	48
Nantucket,	[illegible]43	86,000	26
Natick,	[illegible]14	384,000	37
Needham,	[illegible]06	106,000	32
New Bedford,†	[illegible]00	4,998,000	91
Newburyport,	[illegible]05	564,000	40
Newton,	[illegible]51	1,368,000	50
No. Attleborough,	[illegible]46	166,000	24
Norwood,	[illegible]19	208,000	49
Quincy,	[illegible]70	729,000	37
Randolph and Holbrook,	6,583	290,000	44
Reading,	4,418	222,000	50
Revere and Winthrop,	10,425	723,000	69
Salem,	32,427	2,138,000	66
Sharon,	1,817	34,000	19
Swampscott and Nahant,	4,660	291,000	62
Taunton,	26,513	1,061,000	40
Wakefield and Stoneham,	13,987	553,000	40
Waltham,	21,166	1,055,000	50
Ware,	8,124	209,000	26
Watertown and Belmont,	9,948	477,000	48
Wellesley,	3,951	201,000	51
Whitman,	4,948	189,000	38
Woburn,	14,549	926,000	64

* May to December only.

† The growth of these places has been very rapid since 1890, and the estimates of population given by the superintendents of water works have therefore been used.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected.

January, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, . .	0.50	0.38	0.46	*	1.04	*	*	0.23	*
2, . .	1.05	0.72	0.59	0.88	-	0.76	0.76	0.75	1.12
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	-	-	-	-	-	-
5, . .	0.05	-	0.18	*	-	*	*	-	*
6, . .	0.15	0.16	0.14	0.95	0.63	0.31	0.59	0.85	0.40
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	0.30	*	0.19	*	0.54	*	*	0.35	0.50
10, . .	0.35	0.41	0.17	0.50	-	0.42	0.21	-	-
11, . .	-	-	-	*	-	-	-	-	-
12, . .	-	-	0.02	0.08	-	-	0.01	0.03	-
13, . .	-	-	-	0.02	-	-	-	0.07	0.80
14, . .	-	-	-	*	-	-	-	-	-
15, . .	-	0.08	0.03	0.12	0.10	0.05	0.08	0.40	0.16
16, . .	-	-	-	-	-	-	0.05	-	0.03
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.05	0.03	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.05	-	-	0.03	-	0.03	0.05	0.08	0.05
24, . .	-	-	-	0.03	-	-	-	-	-
25, . .	0.30	0.18	0.15	0.07	-	0.10	0.07	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	*	-	0.50	-
29, . .	0.40	0.40	-	0.28	0.43	0.28	0.35	-	0.65
30, . .	-	0.15	0.31	-	-	-	-	-	-
31, . .	0.20	0.23	0.06	0.02	-	0.06	0.02	-	-
Totals,	3.40	2.74	2.30	2.93	2.74	2.01	2.19	3.16	3.71

February, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	0.15	*	-	0.28	-	*	*	*	*
2, . .	0.10	0.24	0.11	-	-	0.15	0.26	0.42	0.40
3, . .	0.20	0.25	0.23	0.30	0.50	0.32	0.26	0.17	0.10
4, . .	-	-	-	-	-	-	-	-	-
5, . .	-	-	-	-	-	-	-	-	-
6, . .	0.40	*	0.69	*	*	*	*	0.25	*
7, . .	0.50	1.17	0.32	0.56	0.54	0.56	0.36	0.63	1.04
8, . .	-	-	-	-	-	-	-	-	-
9, . .	*	-	-	*	*	*	-	*	*
10, . .	1.10	2.00	1.38	1.16	1.08	0.79	-	1.38	1.20
11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-
13, . .	0.80	0.81	0.60	1.50	1.44	*	*	*	*
14, . .	0.40	0.52	0.83	-	-	0.94	1.47	1.48	1.35
15, . .	0.10	-	-	-	-	-	-	-	-
16, . .	-	-	0.01	-	-	-	-	-	-
17, . .	*	*	-	*	*	*	*	*	*
18, . .	1.00	0.80	0.71	1.18	1.55	0.64	0.80	1.60	1.35
19, . .	*	*	-	*	-	*	0.05	*	*
20, . .	0.30	0.33	0.20	0.08	-	0.27	0.12	0.19	0.24
21, . .	-	-	-	*	-	-	-	-	0.68
22, . .	0.40	0.90	1.10	1.88	2.25	0.67	1.41	0.75	0.87
23, . .	-	-	-	-	-	*	-	-	-
24, . .	0.20	-	0.32	0.22	0.23	0.33	0.32	*	0.60
25, . .	0.20	0.22	0.14	0.31	0.28	*	*	0.66	0.33
26, . .	0.10	-	-	-	-	0.17	0.32	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	0.40	0.26	0.25	0.68	0.44	0.40	0.40	0.19	0.49
Totals,	6.35	7.50	6.89	8.15	8.31	5.24	5.77	7.72	8.15

* Precipitation included in that of following day. † Average of two stations.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

March, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	0.20	-	0.10	-	-	-	-	0.24	0.09
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.10	0.20	-	0.03	-	-	-	*	*
4, . .	0.10	0.25	0.08	0.40	0.20	0.02	0.09	0.20	0.50
5, . .	-	-	-	-	-	-	-	-	-
6, . .	-	-	-	-	-	-	-	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	-	-	-	-	-	-	-	-	-
9, . .	0.90	0.70	0.50	*	*	*	0.83	*	*
10, . .	0.05	-	-	1.39	1.55	0.61	-	*	3.61
11, . .	*	-	0.03	*	*	*	-	*	-
12, . .	0.75	0.50	0.70	0.63	0.30	0.36	0.12	3.77	0.29
13, . .	-	-	-	-	-	-	-	-	-
14, . .	*	-	*	*	*	*	-	-	-
15, . .	1.00	0.90	1.29	0.97	1.00	1.09	0.78	0.58	0.34
16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-
19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	0.15	0.30	0.04	0.04	-	-	0.02	*	0.06
22, . .	0.10	*	-	*	*	-	-	*	*
23, . .	0.10	0.35	0.02	0.22	0.10	0.02	0.04	*	0.31
24, . .	0.10	-	-	-	-	-	0.07	0.41	0.29
25, . .	0.05	-	-	-	-	0.09	-	-	-
26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	0.04
29, . .	-	-	-	-	-	-	-	-	-
30, . .	0.10	0.12	0.01	-	-	-	-	-	0.02
31, . .	-	-	-	-	-	-	-	-	-
Totals,	3.70	3.32	2.77	3.68	3.15	2.19	1.95	5.20	5.55

April, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, .	-	-	0.01	-	-	-	-	-	-
2, .	-	-	-	-	-	-	-	-	-
3, .	-	-	-	-	-	-	-	-	*
4, .	0.10	0.12	0.06	0.16	0.07	0.08	-	0.11	0.35
5, .	-	-	-	-	-	-	-	-	-
6, .	0.25	0.42	0.19	0.40	0.23	0.13	0.33	*	0.20
7, .	0.50	0.60	0.73	*	0.53	*	0.29	*	0.64
8, .	0.45	0.92	0.32	0.42	0.18	0.81	0.18	1.23	0.31
9, .	-	-	-	0.32	0.10	-	0.15	-	-
10, .	-	-	-	-	-	-	-	-	-
11, .	-	-	-	-	-	-	-	-	-
12, .	-	-	-	-	-	-	-	-	-
13, .	0.10	-	0.03	0.03	-	-	-	*	0.10
14, .	0.15	-	0.10	*	*	*	0.42	*	*
15, .	0.65	0.52	0.17	0.71	0.73	0.69	0.42	0.87	0.86
16, .	-	-	-	-	-	-	-	-	-
17, .	-	-	-	-	-	-	-	-	0.02
18, .	-	-	-	-	-	-	-	-	-
19, .	-	-	-	-	-	-	-	-	-
20, .	0.40	*	0.18	*	*	*	*	*	*
21, .	0.70	*	0.77	1.00	1.17	0.71	1.29	0.94	1.42
22, .	0.05	‡1.10	0.08	-	-	-	-	-	0.03
23, .	-	-	-	-	-	0.05	-	-	-
24, .	-	-	-	-	-	-	-	-	-
25, .	0.10	‡0.10	0.02	0.11	0.14	0.07	0.08	0.19	0.22
26, .	-	-	-	-	-	-	-	-	-
27, .	0.30	*	0.12	0.18	0.17	0.28	*	0.31	0.37
28, .	0.05	‡0.28	-	-	-	-	0.18	-	-
29, .	-	-	-	-	-	-	-	-	0.07
30, .	-	-	-	0.06	-	0.02	-	-	0.04
Totals,	3.80	4.06	2.78	3.39	3.32	2.84	3.34	3.65	4.63

* Precipitation included in that of following day. † Average of two stations.

‡ Average of Ludlow, Amherst and Worcester stations.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

May, 18[illegible].

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	0.57	0.63	0.11	*	*	*	0.05	*	–
2, . .	0.25	0.28	0.11	0.40	*	*	0.21	*	*
3, . .	0.27	0.83	0.70	*	*	*	*	*	0.76
4, . .	2.85	1.05	3.63	3.61	3.36	3.11	2.47	3.30	2.12
5, . .	0.10	0.03	–	–	–	–	0.01	–	–
6, . .	–	–	0.04	0.06	–	0.06	0.07	0.21	0.41
7, . .	–	–	–	–	–	–	–	–	–
8, . .	–	–	–	–	–	–	–	–	–
9, . .	–	–	–	–	–	–	–	–	–
10, . .	–	–	–	–	–	–	–	–	–
11, . .	–	–	–	–	–	–	–	–	–
12, . .	–	–	–	–	–	–	–	–	–
13, . .	0.10	0.09	0.35	*	0.50	*	*	*	*
14, . .	0.10	0.37	0.36	0.47	–	0.27	0.78	0.27	0.35
15, . .	–	–	–	–	–	–	–	–	–
16, . .	0.15	0.30	0.59	*	*	*	*	*	*
17, . .	0.50	0.80	1.72	1.65	1.40	1.70	1.61	1.22	[illegible]
18, . .	0.12	0.03	–	0.06	–	0.11	0.06	–	–
19, . .	–	–	–	–	–	–	–	–	0.03
20, . .	–	–	–	–	–	–	–	–	–
21, . .	–	–	–	–	–	–	–	–	–
22, . .	–	–	–	–	–	–	–	–	–
23, . .		*	*	0.04	–	–	–	–	–
24, . .		0.20	0.11	–	–	–	–	0.07	0.07
25, . .		–	–	–	–	–	–	–	–
26, . .		–	–	0.06	0.03	–	–	*	*
27, . .		0.22	0.50	*	0.48	*	*	0.07	0.06
29, . .		–	–	0.61	–	0.31	0.53	–	0.01
29, . .		–	–	–	–	–	–	–	–
30, . .		–	–	–	–	–	–	–	–
31, . .		–	–	–	–	–	–	–	–
Totals,	5.26	4.84	8.25	6.94	5.77	5.55	5.76	6.04	5.06

June, 18[illegible].

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	–	–	–	–	–	–	–	–	–
2, . .	–	–	–	–	–	–	–	–	–
3, . .	[illegible]	–	–	–	–	–	0.02	–	0.02
4, . .	0.06	0.05	0.01	–	–	–	–	–	0.04
5, . .	–	–	–	–	–	–	–	–	–
6, . .	1.10	1.96	0.89	0.29	–	0.60	0.10	–	–
7, . .	[illegible]	–	–	–	–	–	–	–	–
8, . .	–	–	–	–	–	–	–	–	–
9, . .	–	–	–	–	–	–	–	–	*
10, . .	–	–	–	–	–	–	–	0.15	0.16
11, . .	–	–	–	–	–	–	–	–	–
12, . .	–	–	0.06	*	–	–	0.04	–	–
13, . .	–	–	0.04	*	*	*	[illegible]	*	[illegible]
14, . .	–	0.07	0.18	0.90	0.56	0.20	0.09	0.20	0.41
15, . .	–	–	–	–	–	–	–	–	–
16, . .	–	–	–	–	–	–	–	*	0.06
17, . .	0.12	–	0.45	0.32	0.24	*	*	0.27	0.21
18, . .	–	–	–	–	–	0.43	0.34	–	–
19, . .	–	–	–	–	–	–	–	–	–
20, . .	–	–	–	–	–	–	–	–	–
21, . .	–	–	–	–	–	–	–	–	–
22, . .	1.02	1.30	1.20	*	–	*	0.33	1.08	*
23, . .	0.27	0.16	0.18	*	1.50	*	2.12	*	1.27
24, . .	–	–	0.06	0.94	0.04	1.61	0.21	0.59	0.96
25, . .	0.50	*	–	0.02	–	–	–	–	–
26, . .	0.42	0.90	0.08	–	–	–	–	–	–
27, . .	–	–	–	–	–	–	–	–	–
28, . .	–	–	–	–	–	–	–	–	–
29, . .	0.10	0.02	–	–	–	–	–	–	–
30, . .	–	–	–	–	–	–	–	–	–
Totals,	3.73	4.46	2.66	2.47	2.33	2.74	3.31	2.29	3.13

* Precipitation included in that of following day. † Average of two stations.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

July, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	0.05	-	-	-	-	-	-	-	-
2, . .	-	-	-	-	-	-	-	-	-
3, . .	0.02	-	-	-	-	-	-	0.18	0.35
4, . .	-	-	-	-	-	-	-	-	-
5, . .	0.50	0.06	0.14	0.38	0.24	0.85	*	0.47	0.87
6, . .	-	0.50	0.29	-	-	-	0.24	-	-
7, . .	-	-	-	-	-	-	-	-	-
8, . .	0.20	0.19	0.10	0.06	0.07	0.14	-	-	-
9, . .	-	-	-	-	-	-	-	-	0.02
10, . .	0.05	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.30	0.13	0.06	0.12	0.10	0.08	*	*	0.06
13, . .	-	0.18	-	-	-	-	0.02	0.28	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	0.05	-	-	-	-	-	-	-	-
18, . .	-	0.15	-	1.49	0.73	0.21	0.03	0.55	-
19, . .	-	-	0.02	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	-	-	-	-	-	-	-
22, . .	0.20	0.22	0.21	0.26	0.67	0.89	0.99	*	0.17
23, . .	-	-	0.24	0.08	0.16	0.41	0.01	0.24	-
24, . .	-	-	-	-	-	-	-	-	-
25, . .	0.06	0.38	0.11	0.23	0.10	0.32	*	*	0.19
26, . .	0.12	0.51	0.32	0.21	0.03	1.00	0.66	0.31	0.22
27, . .	-	-	-	-	-	-	-	-	-
28, . .	-	-	-	-	-	-	-	-	-
29, . .	0.22	0.32	0.05	-	-	0.13	-	0.07	0.08
30, . .	-	-	-	0.06	-	-	-	-	-
31, . .	-	-	-	0.02	-	-	-	-	-
Totals,	1.77	2.64	1.54	2.91	2.10	3.48	1.95	2.10	1.96

August, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	-	-	0.36	-	-	0.47	-	0.12	0.25
2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-
4, . .	-	-	-	*	*	*	*	*	*
5, . .	-	0.11	0.09	1.65	1.99	0.39	2.48	2.87	1.44
6, . .	0.25	0.04	-	0.42	1.48	0.18	*	-	-
7, . .	0.05	-	-	0.19	0.36	0.32	2.87	0.03	-
8, . .	-	-	1.28	-	-	-	0.36	-	-
9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-
12, . .	0.02	0.02	0.79	0.03	-	0.77	*	-	0.03
13, . .	0.56	-	0.13	-	-	-	0.17	0.07	-
14, . .	-	-	-	-	-	-	-	-	-
15, . .	-	-	-	-	-	-	-	-	-
16, . .	-	-	-	-	-	-	-	-	-
17, . .	0.10	0.20	0.19	0.03	0.09	*	*	0.23	0.36
18, . .	0.24	0.15	0.04	-	0.04	0.42	0.18	-	-
19, . .	-	-	0.02	-	-	-	0.02	-	-
20, . .	0.10	0.20	0.29	*	*	0.13	0.02	*	*
21, . .	0.16	0.60	0.61	1.81	1.84	0.95	1.48	2.65	2.74
22, . .	-	-	-	-	-	-	-	-	-
23, . .	0.02	-	-	-	-	*	-	-	*
24, . .	0.62	0.77	0.83	0.82	0.35	0.50	0.24	0.35	0.36
25, . .	-	0.04	-	-	-	-	-	-	-
26, . .	0.10	0.10	-	-	-	-	-	-	-
27, . .	-	-	1.91	-	-	0.03	-	-	0.02
28, . .	0.10	0.20	-	-	-	-	-	-	-
29, . .	0.78	0.97	1.04	0.43	0.38	0.52	0.18	0.12	0.02
30, . .	-	-	-	-	-	-	-	-	-
31, . .	-	-	-	-	-	-	-	-	-
Totals,	3.10	3.40	7.58	5.38	6.53	4.68	8.00	6.44	5.22

* Precipitation included in that of following day. † Average of two stations.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Continued.

Day of Month.	September, 1898. Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.	Day of Month.	October, 1898. Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.†	New Bedford.
1, . .	-	-	-	*	*	*	*	*	0.72	1, . .	-	-	-	-	-	-	-	-	-
2, . .	0.05	-	0.04	0.29	0.36	0.15	0.31	0.55	-	2, . .	-	-	-	-	-	-	-	-	-
3, . .	-	-	-	-	-	-	-	-	-	3, . .	-	-	-	-	-	-	0.05	-	-
4, . .	-	-	0.02	-	-	-	-	-	-	4, . .	-	-	0.02	0.06	-	-	-	-	0.04
5, . .	-	-	-	-	-	-	-	-	-	5, . .	-	-	-	-	-	0.03	-	-	-
6, . .	-	-	-	-	-	-	-	-	-	6, . .	-	-	-	-	-	-	-	-	-
7, . .	0.75	1.20	0.58	0.54	0.46	0.83	*	-	0.14	7, . .	0.18	0.33	0.28	0.11	-	0.17	-	0.03	0.03
8, . .	0.23	-	0.02	-	-	-	0.47	0.13	-	8, . .	-	-	-	-	-	-	-	-	-
9, . .	-	-	-	-	-	-	-	-	-	9, . .	-	-	-	-	-	-	-	-	-
10, . .	-	-	-	-	-	-	-	-	-	10, . .	-	-	-	-	-	-	-	-	-
11, . .	-	-	-	-	-	-	-	-	-	11, . .	-	-	-	-	-	-	-	-	-
12, . .	-	-	-	-	-	-	-	-	-	12, . .	-	-	-	-	-	-	-	-	-
13, . .	-	-	-	-	-	-	-	-	-	13, . .	-	-	-	-	*	-	-	-	-
14, . .	-	-	-	-	-	-	-	-	-	14, . .	0.94	1.84	1.16	0.78	1.39	0.72	0.68	0.74	0.62
15, . .	0.34	0.35	0.02	0.03	0.02	-	-	-	0.03	15, . .	-	-	-	-	-	-	-	-	-
16, . .	0.48	0.56	0.41	0.63	0.56	0.54	0.58	0.70	0.46	16, . .	-	-	-	-	-	-	-	-	-
17, . .	-	-	-	-	-	-	-	-	-	17, . .	-	-	-	-	-	-	-	-	-
18, . .	-	-	-	-	-	-	-	-	-	18, . .	-	-	-	-	-	-	-	-	-
19, . .	0.11	-	0.15	0.21	0.28	0.09	0.07	0.23	0.47	19, . .	-	-	-	-	-	-	-	-	-
20, . .	-	-	-	-	-	-	-	-	-	20, . .	-	-	-	-	-	-	-	-	-
21, . .	-	-	0.01	-	-	-	-	-	-	21, . .	-	-	-	-	-	-	-	-	-
22, . .	-	-	0.02	-	-	-	-	*	0.03	22, . .	-	-	-	*	-	-	-	-	-
23, . .	0.06	0.11	-	0.03	0.05	0.02	-	0.06	0.04	23, . .	0.49	0.65	0.81	*	*	*	*	*	0.04
24, . .	-	-	-	-	-	-	-	-	-	24, . .	0.95	1.90	1.51	2.27	2.02	2.00	2.54	1.81	1.76
25, . .	0.10	0.22	0.25	-	0.12	0.10	*	0.36	0.41	25, . .	-	-	-	-	-	-	-	-	-
26, . .	-	-	-	-	-	-	0.06	-	0.22	26, . .	-	-	-	-	-	-	-	-	-
27, . .	-	-	-	-	-	-	-	*	*	27, . .	0.10	0.06	0.05	*	*	*	-	-	-
28, . .	-	-	-	-	-	-	-	0.15	0.50	28, . .	1.50	1.90	1.20	0.91	0.29	0.84	-	0.23	0.12
29, . .	0.30	0.15	0.05	0.07	0.05	0.08	-	-	-	29, . .	-	-	-	-	-	-	-	-	-
30, . .	-	0.03	0.07	-	-	-	-	0.02	0.02	30, . .	-	-	-	-	-	-	-	-	-
										31, . .	-	-	-	-	-	-	-	-	-
Totals,	2.42	2.62	1.64	1.80	1.85	1.81	1.44	2.20	3.04	Totals,	4.16	6.68	5.03	4.08	3.70	3.76	3.27	2.81	2.61

* Precipitation included in that of following day. † Average of two stations.

Daily Rainfall in Inches at Nine Places in Massachusetts, Geographically selected — Concluded.

November, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, .	-	-	-	-	-	-	-	-	-
2, .	-	-	-	-	-	-	-	-	-
3, .	0.04	0.06	0.01	-	-	0.01	-	-	0.02
4, .	0.34	0.40	0.41	*	*	-	*	*	*
5, .	0.31	0.30	0.22	0.81	0.71	0.48	0.60	1.36	0.93
6, .	-	-	-	-	-	-	-	-	-
7, .	-	-	-	-	-	-	-	-	-
8, .	-	-	-	-	-	-	-	-	-
9, .	-	-	-	-	-	-	-	-	-
10, .	-	-	-	-	-	-	-	-	-
11, .	-	-	-	-	-	-	-	-	-
12, .	-	-	-	-	-	-	-	-	-
13, .	0.08	0.09	-	-	-	-	-	-	0.03
14, .	-	-	-	-	-	-	-	-	-
15, .	0.13	0.20	0.10	0.18	0.19	0.10	0.18	0.37	0.36
16, .	-	-	-	-	-	-	-	-	-
17, .	-	-	-	-	-	-	-	-	-
18, .	-	-	-	-	-	-	-	0.02	0.04
19, .	-	-	-	-	-	-	-	-	-
20, .	-	-	-	-	0.02	0.08	-	-	-
21, .	-	-	-	*	-	-	-	-	-
22, .	0.47	0.57	0.92	0.70	0.65	0.76	0.65	0.63	0.62
23, .	-	-	-	-	-	-	-	-	-
24, .	-	-	-	-	-	-	-	-	-
25, .	-	-	-	-	-	-	-	-	-
26, .	-	-	-	-	-	-	-	-	-
27, .	-	-	-	-	-	-	-	-	-
28, .	0.30	0.78	0.82	0.54	0.43	0.39	0.34	0.59	0.71
29, .	-	-	-	-	-	-	-	-	-
30, .	-	-	-	-	-	-	-	-	-
Tot.,	1.62	2.40	2.48	2.23	2.00	1.82	1.77	2.97	2.71

December, 1893.

Day of Month.	Ludlow.	Gilbertville.	Fitchburg.	Framingham.	Chestnut Hill, Boston.	Lawrence.	Salem.	Taunton.	New Bedford.
1, .	0.28	0.85	0.30	0.40	0.39	0.33	0.41	0.52	0.56
2, .	0.10	-	-	-	-	-	-	-	-
3, .	1.87	*	1.40	*	*	*	1.20	*	0.15
4, .	-	2.00	0.78	1.45	1.56	2.96	0.39	1.57	1.84
5, .	0.15	*	0.66	0.70	0.67	*	*	1.96	*
6, .	-	0.30	-	-	-	0.63	1.05	-	1.00
7, .	-	-	-	-	-	-	-	-	-
8, .	-	-	-	-	-	-	-	-	-
9, .	0.25	0.30	0.10	0.42	*	*	*	0.47	*
10, .	-	-	-	-	0.35	0.29	0.34	-	0.41
11, .	-	-	-	0.04	-	-	-	-	-
12, .	0.05	0.18	0.09	-	-	0.08	0.06	-	-
13, .	-	-	-	-	-	-	-	-	-
14, .	0.10	-	0.09	-	*	*	*	*	*
15, .	0.45	*	0.30	-	*	*	0.42	0.74	1.20
16, .	0.44	*	0.95	-	*	*	0.21	*	*
17, .	0.31	1.80	-	1.64	1.54	1.22	0.73	0.83	1.17
18, .	-	-	-	0.04	-	-	-	-	-
19, .	0.02	0.30	0.06	-	0.03	0.04	0.08	0.15	0.11
20, .	-	-	-	-	-	-	-	-	-
21, .	-	-	-	-	-	-	-	-	-
22, .	-	-	-	-	-	-	-	-	-
23, .	0.14	0.17	0.06	0.06	0.08	0.05	0.02	-	0.02
24, .	0.02	-	-	-	-	-	-	-	-
25, .	-	-	-	-	-	-	-	-	-
26, .	-	-	-	-	-	-	-	-	0.02
27, .	-	-	-	-	-	-	-	-	-
28, .	0.05	-	0.01	-	-	0.01	-	-	0.02
29, .	0.12	0.18	0.06	0.05	0.05	0.11	0.09	0.10	0.07
30, .	0.10	-	0.05	-	*	-	-	0.29	0.07
31, .	0.11	0.10	0.04	0.14	0.24	0.12	0.20	0.09	0.31
Tot.,	4.56	5.68	4.95	4.94	4.91	5.84	5.22	6.72	6.95
Totals for Year,	43.87	50.84	48.86	48.90	46.71	41.96	43.97	50.30	52.72

* Precipitation included in that of following day.

Flow of Streams.

The flow of the streams of the State during the year 1893, as indicated by the flow of Sudbury River, was a very little less than the average for the past nineteen years, but the distribution was very uneven. The flow was above the average in March, April and May, in the latter month being nearly twice as great as that recorded in the same month for any previous year, but in all the remaining months the flow was below the average, and from June to November, inclusive, was the smallest since 1887.

The effect of this distribution of the flow was the opposite of that of the previous year. In 1893 the drought was felt most by the cities and towns deriving their supply from large watersheds, with comparatively small storage, from which water usually runs to waste in the spring; while those communities taking their supply from large ponds fed by comparatively small watersheds experienced no unusual inconvenience, owing to the large amount of water collected during the spring months.

In order to show the relation between the flow of the Sudbury River during each month of 1893 and the normal flow of the same river, as deduced from fifteen years' observations from 1879 to 1893, inclusive, the following table has been prepared. The area of the watershed of the Sudbury River above the point of measurement is 75.2 square miles.

Table showing the Average Monthly Flow of Sudbury River for the Year 1893, in Cubic Feet per Second per Square Mile of Drainage Area, also Departures from the Normal Flow.

Month.	Normal Flow. Cubic Feet per Second per Square Mile.	Actual Flow in 1893. Cubic Feet per Second per Square Mile.	Excess or Deficiency. Cubic Feet per Second per Square Mile.
January,	2.115	0.670	—1.445
February,	3.190	2.386	—0.804
March,	4.159	5.021	+0.862
April,	2.951	3.288	+0.337
May,	1.807	4.461	+2.654
June,	0.736	0.680	—0.056
July,	0.279	0.245	—0.034
August,	0.430	0.279	—0.151
September,	0.432	0.168	—0.264
October,	0.790	0.343	—0.447
November,	1.119	0.493	—0.626
December,	1.422	1.233	—0.189
Average,	1.611	1.604	—0.007

The next table shows the weekly fluctuations, during 1893, in the flow of the two streams most carefully measured, namely, the Sudbury and the Merrimack. The flow of these streams, particularly the Sudbury, will serve to indicate the condition of other streams in eastern Massachusetts.

Table showing the Average Weekly Flow of the Sudbury and Merrimack Rivers, in Cubic Feet per Second per Square Mile of Drainage Area, for the Year 1893.

Week ending Sunday.	Sudbury River. — Cubic Feet per Second per Square Mile.	Merrimack River. — Cubic Feet per Second per Square Mile.	Week ending Sunday.	Sudbury River. — Cubic Feet per Second per Square Mile.	Merrimack River. — Cubic Feet per Second per Square Mile.
Jan 1,	0.514	0.837	July 2,	0.516	0.969
8,	1.132	1.017	9,	0.312	0.604
15,	0.626	0.610	16,	0.211	0.503
22,	0.460	0.526	23,	0.258	0.470
29,	0.412	0.470	30,	0.179	0.535
Feb. 5,	0.586	0.487	Aug. 6,	0.275	0.441
12,	4.937	1.067	13,	0.251	0.469
19,	2.580	1.678	20,	0.181	0.437
26,	1.237	0.982	27,	0.389	0.661
Mar. 5,	1.248	0.844	Sept. 3,	0.234	1.000
12,	2.805	0.936	10,	0.184	0.614
19,	10.061	4.126	17,	0.175	0.481
26,	5.164	2.569	24,	0.128	0.617
Apr. 2,	4.228	3.239	Oct. 1,	0.162	0.515
9,	3.610	3.593	8,	0.165	0.515
16,	3.472	4.630	15,	0.184	0.534
23,	3.350	3.916	22,	0.197	0.777
30,	2.677	3.490	29,	0.783	1.375
May 7,	7.854	7.009	Nov. 5,	0.538	1.515
14,	4.209	5.087	12,	0.566	0.822
21,	5.003	5.808	19,	0.425	0.702
28,	2.140	3.000	26,	0.453	0.742
June 4,	1.161	1.679	Dec. 3,	0.645	1.083
11,	0.636	1.206	10,	1.091	1.194
18,	0.676	1.011	17,	0.909	1.200
25,	0.657	0.929	24,	1.091	0.716
			31,	1.991	1.000

In the annual report of the State Board of Health for the year 1890 (pages 338 to 340) a table was printed giving records of the rainfall upon the Sudbury River watershed, and its yield, expressed in inches in depth upon the watershed (inches of rainfall collected), for the sixteen years from 1875 to 1890 inclusive. The corresponding records for the years 1891 and 1892, as taken from the annual reports of the Boston Water Board, were given in the annual report for 1892. In the following table is given the record for 1893, together with the average of the records for the whole nineteen years.

Rainfall Received and Collected on the Sudbury River Watershed.

MONTH.	1893.			MEAN FOR 19 YEARS, 1875-1893.		
	Rainfall.	Rainfall Collected.	Per Cent. Collected.	Rainfall.	Rainfall Collected.	Per Cent. Collected.
January,	2.925	0.773	26.44	4.351	2.227	51.18
February,	8.195	2.485	30.32	4.292	3.184	74.18
March,	3.670	5.789	157.74	4.603	5.133	111.51
April,	3.605	3.668	101.75	3.235	3.540	109.43
May,	6.610	5.143	77.81	3.445	2.125	61.68
June,	2.380	0.759	31.88	2.983	0.848	28.43
July,	2.570	0.282	10.96	3.723	0.333	8.94
August,	5.415	0.322	5.95	4.327	0.523	12.09
September,	1.735	0.187	10.75	3.088	0.436	14.12
October,	4.065	0.395	9.72	4.193	0.909	21.68
November,	2.195	0.550	25.07	4.042	1.485	36.74
December,	4.860	1.421	29.23	3.633	1.811	49.85
TOTALS AND AVERAGES,	48.225	21.774	45.15	45.915	22.554	49.12

The Sudbury River records are particularly valuable as a basis for estimating the yield of other watersheds in Massachusetts, both on account of the accuracy with which the measurements have been made during the whole nineteen years, and the absence of abnormal conditions which would unfavorably affect the results. It is therefore thought advisable to publish in the following table those portions of the records relating to the yield of this watershed for each of the nineteen years; and in doing so the flow from the watershed is expressed in gallons per day per square mile, instead of inches in depth of rainfall collected, in order to render the table more convenient for use in estimating the probable yield of watersheds used as sources of water supply.

Yield of the Sudbury River Watershed in Gallons Per Day Per Square Mile.*

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
January,	103,000	643,000	658,000	1,810,000	700,000	1,121,000	415,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000
March,	1,604,000	4,435,000	4,813,000	3,507,000	2,330,000	1,374,000	4,004,000
April,	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,168,000	1,546,000
May,	1,188,000	1,139,000	1,391,000	1,394,000	1,114,000	514,000	965,000
June,	870,000	222,000	597,000	506,000	418,000	176,000	1,338,000
July,	321,000	183,000	202,000	128,000	158,000	177,000	276,000
August,	396,000	405,000	121,000	475,000	395,000	119,000	148,000
September,	207,000	184,000	60,000	160,000	141,000	80,000	197,000
October,	646,000	234,000	632,000	516,000	71,000	101,000	186,000
November,	1,802,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000
December,	584,000	454,000	1,289,000	3,177,000	462,000	175,000	775,000
Average for whole year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000
Av'ge for driest six months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000

MONTH.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
January,	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000	1,053,000
February,	2,403,000	1,033,000	2,842,000	1,354,000	4,800,000	2,829,000	1,951,000
March,	2,839,000	1,611,000	3,785,000	1,572,000	2,059,000	2,868,000	3,237,000
April,	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000	2,645,000
May,	1,292,000	938,000	1,030,000	1,836,000	720,000	1,009,000	1,632,000
June,	529,000	300,000	417,000	426,000	208,000	414,000	422,000
July,	86,000	115,000	224,000	62,000	115,000	114,000	117,000
August,	55,000	78,000	257,000	240,000	94,000	214,000	380,000
September,	306,000	91,000	44,000	121,000	118,000	111,000	1,155,000
October,	299,000	186,000	83,000	336,000	146,000	190,000	1,999,000
November,	210,000	205,000	175,000	1,178,000	673,000	368,000	2,758,000
December,	314,000	193,000	925,000	1,174,000	1,020,000	643,000	3,043,000
Average for whole year,	862,000	533,000	1,129,000	901,000	1,087,000	1,154,000	1,697,000
Av'ge for driest six months,	211,000	145,000	200,000	391,000	223,000	234,000	953,000

MONTH.	1889.	1890.	1891.	1892.	1893.	Mean for 19 Years, 1875-1893, Inclusive.
January,	2,782,000	1,254,000	3,018,000	1,870,000	433,000	1,248,000
February,	1,195,000	1,529,000	3,486,000	943,000	1,542,000	1,958,000
March,	1,339,000	3,643,000	4,453,000	1,955,000	3,245,000	2,879,000
April,	1,410,000	1,875,000	2,397,000	871,000	2,125,000	2,051,000
May,	880,000	1,366,000	582,000	1,259,000	2,883,000	1,191,000
June,	653,000	568,000	414,000	428,000	440,000	491,000
July,	633,000	108,000	149,000	214,000	158,000	186,000
August,	1,432,000	132,000	163,000	280,000	181,000	293,000
September,	824,000	458,000	203,000	229,000	108,000	252,000
October,	1,230,000	2,272,000	210,000	126,000	221,000	510,000
November,	1,941,000	1,215,000	305,000	697,000	319,000	860,000
December,	2,241,000	997,000	544,000	485,000	797,000	1,015,000
Average for whole year,	1,383,000	1,285,000	1,315,000	781,000	1,037,000	1,073,000
Av'ge for driest six months,	944,000	747,000	239,000	327,000	237,000	397,000

* The area of the Sudbury River watershed used in making up these records included water surfaces amounting to about one per cent. of the whole area, from 1875 to 1878 inclusive, and subsequently increasing by the construction of storage reservoirs to about three per cent. in 1886. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

ON THE

AMOUNT AND CHARACTER

OF

ORGANIC MATTER IN SOILS

AND ITS BEARING ON THE

STORAGE OF WATER IN RESERVOIRS.

By THOMAS M. DROWN, M.D., Chemist of the Board.

ON THE AMOUNT AND CHARACTER OF ORGANIC MATTER IN SOILS AND ITS BEARING ON THE STORAGE OF WATER IN RESERVOIRS.

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Many statements have been made in previous reports of the Board, concerning the injurious effect on impounded water of the organic matter in the bottoms and sides of reservoirs, and great stress has been laid on the importance of removing all vegetation, as well as the upper layers of the soil, before filling a new basin with water.*

In order to determine in any case just how far it is necessary to go in the removal of the surface soil, a knowledge of the composition of the soil, based on chemical analysis, is a much surer guide than the unaided eye. It is not merely a question of the effective cleaning of the bottom and sides of the reservoir, but also of avoiding the expense involved in stripping the soil to a greater depth than is necessary. In connection with the investigations of the State Board of Health relative to a water supply for the city of Boston and its suburbs, surveys have been made for an immense storage reservoir on the south branch of the Nashua River above Clinton, and it was thought desirable that a thorough knowledge of the character of the soil should be obtained as a basis for determining the amount which it would be necessary to remove to obtain a clean bottom and sides practically free from organic matter. Samples of soils, representing sections of the ground to a depth of three feet, were taken at nine places in Clinton, Sterling, West Boylston, and Boylston, and in one case at the bottom of a mill pond.

Each of these nine sections were divided into six or seven samples for analysis, the upper portion being divided into thin layers of two to three inches, the lower portions, with less organic matter, into layers of six inches to one foot in depth.

* Compare special report upon the examination of water supplies, 1890, pages 748, 772, 773; report for 1891, page 381.

The amount of organic matter in these samples was determined (after careful drying to a constant weight at 100° C.) by heating the samples to a bright red heat. The loss on ignition thus obtained represents approximately the organic matter in the samples. But in order to get a better knowledge of the character of this organic matter, the amounts of carbon and of nitrogen were also determined in each sample — the former by combustion in oxygen, the latter by the Kjeldahl method. In series 9 and 10, the amount of hydrogen was also determined.*

Owing to the heterogeneous character of many of the samples, composed often of a mixture of soil, roots and large stones, it is sometimes extremely difficult to get a sample for analysis that shall fairly represent the layer in question. Perhaps some of the apparent irregularities in the results may be due to this cause. But though this difficulty is inherent in the investigation it is not believed to seriously affect the results, or the conclusions drawn from them.

The results obtained in the analyses of the nine sections of soil, and the deposit from the bottom of the mill pond, are given in the accompanying tables. The largest amount of organic matter found was from a swamp at the head of Boylston Mill Pond (Series 7), and the next largest in amount from the hillside near the site of the proposed dam (Series 4). The other series, from very dissimilar ground, did not differ very widely in the amount of organic matter present, although they included both unwooded and uncultivated land and wooded and manured pasture land. But in all the series there is usually a rapid falling off in the amount of the organic matter below a depth of nine to eleven inches. At the depth of three feet the amount of organic matter, as shown by the loss on ignition, in no case reaches two per cent., and in the majority of the cases it is below one per cent. The mud taken from the bottom of the Mill Pond at different points contained very variable amounts of organic matter, from almost nothing at one place in the shallow portion to nearly 15 per cent. in the deeper portion.

It was thought that the relation of the amount of nitrogen to the amount of carbon in the organic matter might throw some light on its character and its likelihood to undergo decomposition. This relation is given to the column headed $\frac{C}{N}$. The only series in which the nitrogen ratio is noticeably higher than the rest is No. 5, from

* All the analyses in this investigation were made by Miss Elizabeth Mason.

low pasture land. Series Nos. 4 and 6, both from hillsides, show a noticeably high carbon ratio, and the others are not very dissimilar in their proportion of carbon to nitrogen.

An attempt was made to imitate the conditions which would obtain if the reservoir should be filled with water without removing the soil, in order to determine what would be the effect of each of the soils examined on water in contact with it. It is obvious that no laboratory experiment could exactly reproduce the conditions which would exist in a reservoir. Thus it would not be easy to imitate the period of long stagnation of the water during the summer, when the deeper layers of the water are in contact with the soil, without an opportunity to get a fresh supply of oxygen from the air. Still it was thought that some idea of the effect of the different soils on the water could be obtained by treating the samples with water for a definite time, and then examining the solutions thus obtained with respect to the character of the organic matter dissolved. In order to hasten the action of the water on the soils, it was heated to 65° C., and the time of contact at this temperature was six hours. The waters were then filtered and the filtrate examined by the usual methods used in the sanitary analysis of water. After standing one week the waters were again tested for free ammonia, to ascertain the amount of decomposition which had gone on in this time, thus obtaining information as to the character of the organic matter dissolved. The *actual amounts* of organic matter found in these solutions, as indicated by the albuminoid ammonia and oxygen consumed, are not especially significant, since they would probably have been very different if another temperature or a greater or less time of treatment had been adopted. But a comparison of the amounts dissolved from the soils in each series, and a comparison of the series with each other, yield information as to the relative facility with which each of the samples examined give up organic matter to water with which it comes in contact.

In the various experiments tried the proportion of soil to water differed, and in some cases distilled water was used and in others Cochituate water. But in the tables the results of series 1 to 8 have been calculated to represent the effect of the treatment of 100 grams of soil with two litres of pure water at 65° C. for six hours. In series 9 and 10 no heat was employed. In these experiments 250 grams of each sample were placed in a bottle with two litres of pure distilled water. After one week, one litre of this water was filtered

off and analyzed, and at the end of the second week the remaining water was examined.

In comparing these tables of analyses of the waters with the corresponding tables giving the percentage determinations of loss on ignition, carbon and nitrogen, a general agreement will be noticed; that is to say, the samples containing the most organic matter give, as a rule, the most concentrated solutions of organic matter. But the analyses do not indicate more than a very general correspondence of this kind. It will also be noted that the amount of decomposition going on in these solutions, indicated by the increase of free ammonia on standing one week, is, in general, also proportional to the amount of organic matter present. The most notable increase in the free ammonia is generally in the solutions prepared from the surface samples. In solutions from the deeper samples there is generally a decrease of free ammonia indicating doubtless its oxidation to nitrates. The samples from the bottom of the Mill Pond (series 8) give solutions which have little or no tendency to develop free ammonia. This might be expected from the fact that the organic matter they contain has long been in contact with water.

The effect of the soil on the color of water is given both for colorless distilled water, and for Cochituate water having an original color of about 0.55 on the scale used in the analyses of the State Board of Health. In these color determinations the water was not heated, and the length of time of contact with the soil was about 18 hours. It will be noticed that in some cases the deeper samples actually diminished the color of the Cochituate water.

As a preliminary conclusion, based on the facts determined in this investigation, it may be said that the effect of the organic matter in these various soils on the water in contact with them is simply a question of its amount, and that its origin and composition seem to be without marked influence. The watershed from which the samples were taken is very sparsely populated, and the organic matter in all cases is mainly of vegetable origin.

It is probable, therefore, that we need only concern ourselves with the amount of organic matter in a soil of this character in determining the necessity of its removal, and as a provisional standard we may perhaps fix 1.5 to 2 per cent. of organic matter, as determined by the loss on ignition of the sample dried at 100° C., as the permissible limit of organic matter that may be allowed to remain on the bottom and sides of a reservoir.

Series 1.

From a Cornfield One-quarter Mile below Clarendon Mills, West Boylston. Cultivated Fertilized Ground in Bottoms. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
1a. Surface to 2 in. below, ...	8.54	5.12	0.47	10.9
1b. 2 in. to 4 in. below surface, . . .	6.83	3.55	0.21	16.9
1c. 4 in. to 6 in. below surface, . . .	7.43	3.47	0.30	11.5
1d. 6 in. to 9 in. below surface, . . .	4.27	2.03	0.21	9.7
1e. 9 in. to 14 in. below surface, . . .	1.37	0.26	0.04	6.5
1f. 14 in. to 20 in. below surface, . . .	1.07	0.16	0.02	8.0
1g. 3 feet below surface, ...	0.78	0.15	0.05	3.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
1a. Surface to 2 in. below, . .	0.0343	0.1107	0.1914	2.2368	Not det'd.	Not det'd.
1b. 2 in. to 4 in. below surface, .	0.0424	0.0984	0.1437	2.0837	"	"
1c. 4 in. to 6 in. below surface, .	0.0317	0.0913	0.1538	2.5290	"	"
1d. 6 in. to 9 in. below surface, .	0.0317	0.0359	0.0881	0.9738	"	"
1e. 9 in. to 14 in. below surface, .	0.0212	0.0076	0.0351	0.4947	"	"
1f. 14 in. to 20 in. below surface, .	0.0194	0.0076	0.0189	0.2515	"	"
1g. 3 feet below surface, . .	0.0229	0.0374	0.0105	0.2763	"	"

SERIES 2.

From a very Steep Slope One-quarter Mile below Clarendon Mills, West Boylston. Not wooded or cultivated. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
2*a*. Surface to 2 in. below,	4.55	2.26	0.14	16.1
2*b*. 2 in. to 4 in. below surface,	10.19	5.00	0.27	18.5
2*c*. 4 in. to 7 in. below surface,	7.62	2.52	0.36	7.0
2*d*. 7 in. to 10 in. below surface,	7.70	2.93	0.21	14.0
2*e*. 10 in. to 16 in. below surface,	1.01	0.18	0.05	3.6
2*f*. 16 in. to 22 in. below surface,	1.63	0.24	0.13	1.8
2*g*. 3 feet below surface,	0.80	0.23	0.03	7.7

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
2*a*. Surface to 2 in. below,	0.0340	0.0669	0.0852	1.4732	0.40	0.90
2*b*. 2 in. to 4 in. below surface,	0.0227	0.1215	0.1872	2.3334	0.48	1.00
2*c*. 4 in. to 7 in. below surface,	0.0227	0.0335	0.1261	2.3092	0.35	0.85
2*d*. 7 in. to 10 in. below surface,	0.0178	0.0062	0.1349	2.6945	0.52	0.85
2*e*. 10 in. to 16 in. below surface,	0.0307	0.0130	0.0205	0.5428	0.15	0.70
2*f*. 16 in. to 22 in. below surface,	0.0190	0.0000	0.0196	0.4560	-	-
2*g*. 3 feet below surface,	0.0323	0.0213	0.0267	0.3756	0.00	0.45

Series 3.

From Pasture Land One Mile North of South Clinton Station. Sandy and Gravelly and Nearly Level. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
3*a*. Surface to 2 in. below, ...	7.85	3.51	0.27	13.0
3*b*. 2 in. to 4 in. below surface, . . .	5.85	2.18	0.24	9.1
3*c*. 4 in. to 6 in. below surface, . . .	4.93	2.28	0.20	11.4
3*d*. 6 in. to 11 in. below surface, . . .	1.73	0.50	0.03	16.7
3*e*. 11 in. to 16 in. below surface, . . .	1.43	0.13	0.04	3.3
3*f*. 16 in. to 36 in. below surface, . . .	0.81	0.02	0.02	1.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
3*a*. Surface to 2 in. below, . .	0.0341	0.0541	0.1540	1.4423	0.30	0.60
3*b*. 2 in. to 4 in. below surface, .	0.0457	0.0693	0.1041	1.4855	0.22	0.65
3*c*. 4 in. to 6 in. below surface, .	0.0857	0.0745	0.0888	1.2000	0.15	0.60
3*d*. 6 in. to 11 in. below surface, .	0.0427	0.0138	0.0321	0.4361	0.12	0.50
3*e*. 11 in. to 16 in. below surface, .	0.0400	0.0290	0.0125	0.1689	0.00	0.18
3*f*. 16 in. to 36 in. below surface, .	0.0214	0.0121	0.0067	0.1000	0.00	0.33

Series 4.

From a very Steep, Clayey Hillside near Site of Proposed Dam. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100°C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
4*a*. Surface to 2 in. below,	17.79	8.19	0.56	14.6
4*b*. 2 in. to 4 in. below surface,	11.04	5.85	0.38	15.4
4*c*. 4 in. to 6 in. below surface,	8.55	4.31	0.12	35.9
4*d*. 6 in. to 11 in. below surface,	4.04	1.26	0.05	25.2
4*e*. 11 in. to 16 in. below surface,	2.80	0.47	0.03	15.7
4*f*. 3 feet below surface,	1.76	0.10	0.01	10.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
4*a*. Surface to 2 in. below,	0.0622	0.3555	0.4240	7.7338	0.30	0.75
4*b*. 2 in. to 4 in. below surface,	0.2581	0.4749	0.3032	8.0323	0.30	0.75
4*c*. 4 in. to 6 in. below surface,	0.0454	0.1513	0.1968	4.2622	0.48	0.80
4*d*. 6 in. to 11 in. below surface,	0.0071	0.0267	0.0542	1.0422	0.32	0.55
4*e*. 11 in. to 16 in. below surface,	0.0077	0.0154	0.0369	0.5427	0.12	0.55
4*f*. 3 feet below surface,	0.0138	0.0092	0.0155	0.3000	0.40	0.70

Series 5.

From Level Pasture Land near River, Half a Mile East of Boylston Station. Silt Formation. Samples taken from Surface to Three Feet Six Inches below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
5*a*. Surface to 2 in. below, ...	9.40	4.19	0.43	9.7
5*b*. 2 in. to 4 in. below surface, . . .	3.94	1.33	0.15	8.9
5*c*. 4 in. to 7 in. below surface, . . .	3.04	1.02	0.11	9.3
5*d*. 7 in. to 10 in. below surface, . . .	2.12	0.63	0.10	6.3
5*e*. 10 in. to 15 in. below surface, . . .	2.51	0.73	0.09	8.1
5*f*. 15 in. to 20 in. below surface, . . .	0.88	0.16	0.03	5.3
5*g*. 3 ft. 6 in. below surface, ...	1.09	0.21	0.02	10.5

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
5*a*. Surface to 2 in. below, . .	0.0349	0.2573	0.5556	2.7619	0.20	0.70
5*b*. 2 in. to 4 in. below surface, .	0.0533	0.0195	0.0636	1.5876	0.20	0.65
5*c*. 4 in. to 7 in. below surface, .	0.0380	0.0099	0.0670	0.8444	0.20	0.70
5*d*. 7 in. to 10 in. below surface, .	0.0166	0.0325	0.0316	0.2882	0.20	0.60
5*e*. 10 in. to 15 in. below surface, .	0.0182	0.0117	0.0519	0.6127	0.25	0.70
5*f*. 15 in. to 20 in. below surface, .	0.0188	0.0041	0.0199	0.2726	0.00	0.45
5*g*. 3 ft. 6 in. below surface, . .	0.0295	0.0533	0.0116	0.2036	0.05	0.50

Series 6.

From Three-quarters of a Mile West of Boylston Centre on Wooded Hillside East of Muddy Brook. Samples taken from Surface to Three Feet below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
6*a*. Surface to 2 in. below,	9.69	8.98	0.11	81.2
6*b*. 2 in. to 4 in. below surface,	4.81	1.30	0.04	32.5
6*c*. 4 in. to 7 in. below surface,	4.06	0.91	0.11	8.3
6*d*. 7 in. to 10 in. below surface,	2.88	0.69	0.02	34.5
6*e*. 10 in. to 16 in. below surface,	2.50	0.30	0.02	15.0
6*f*. 3 ft. below surface,	1.77	0.16	0.01	16.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
6*a*. Surface to 2 in. below,	0.0800	0.2921	0.4726	7.0009	0.60	1.00
6*b*. 2 in. to 4 in. below surface,	0.0392	0.0574	0.0770	1.5740	0.30	0.70
6*c*. 4 in. to 7 in. below surface,	0.0361	0.0323	0.0519	1.0977	0.38	0.60
6*d*. 7 in. to 10 in. below surface,	0.0209	0.0116	0.0243	0.3368	0.10	0.53
6*e*. 10 in. to 16 in. below surface,	0.0340	0.0142	0.0288	0.5060	0.20	0.55
6*f*. 3 ft. below surface,	0.0142	0.0077	0.0110	0.1478	0.00	0.10

SERIES 7.

From Swamp at Head of Boylston Millpond, about Three-quarters of a Mile above Boylston Station. Samples taken from Surface to Three Feet Three Inches below Surface. All Samples dried at 100° C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
7a. Surface to 2 in. below, ...	22.31	12.53	0.96	13.0
7b. 2 in. to 4 in. below surface, . . .	24.59	13.05	0.54	24.2
7c. 4 in. to 8 in. below surface, . . .	17.12	8.75	0.86	10.2
7d. 8 in. to 12 in. below surface, . . .	9.14	3.96	0.21	18.9
7e. 12 in. to 21 in. below surface, . . .	3.93	1.44	0.09	16.0
7f. 21 in. to 39 in. below surface, . . .	1.98	0.51	0.04	12.8
7g. 39 in. below surface, ...	0.66	0.06	0.00	0.0

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
7a. Surface to 2 in. below, . .	0.1360	0.4000	0.4970	6.4000	0.40	0.70
7b. 2 in. to 4 in. below surface, .	0.1486	0.5429	0.4486	7.4286	0.50	0.90
7c. 4 in. to 8 in. below surface, .	0.1360	0.3440	0.4970	4.6000	0.12	0.55
7d. 8 in. to 12 in. below surface, .	0.0274	0.0709	0.0937	2.7429	0.50	1.00
7e. 12 in. to 21 in. below surface, .	0.0305	0.0267	0.0438	1.0857	0.30	0.70
7f. 21 in. to 39 in. below surface, .	0.0173	0.0220	0.0502	0.8471	0.10	0.55
7g. 39 in. below surface, . .	0.0179	0.0245	0.0080	0.1365	0.02	0.45

Series 8.

From Bottom of Oakdale Millpond from Depths of Three to Twelve Feet. All Samples dried at 100°C.

	Loss on Ignition. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio $\frac{c}{n}$
8*a*. Near head in 8 ft. of water, ...	0.91	0.07	0.01	7.0
8*b*. ¼ mile below head in 5 ft. of water, ...	0.11	0.06	0.00	0.0
8*c*. ½ mile below head in 7 ft. of water, ...	10.16	4.10	0.36	11.4
8*d*. ¾ mile from head in 9 ft. of water, ...	10.45	4.17	0.35	11.9
8*e*. 500 ft. above W. & N. R.R. in 12 ft. of water, . .	14.75	6.56	0.53	12.4
8*f*. 500 ft. below W. & N. R.R. in 12 ft. of water, . .	4.72	2.18	0.15	14.5

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.	Free Ammonia after Standing One Week.	Albuminoid Ammonia.	Oxygen Consumed.	Color with Distilled Water.	Effect of Soils on Color of Cochituate Water of Color 0.55.
8*a*. Near head in 8 ft. of water, .	0.0186	0.0121	0.0251	0.2224	0.01	0.55
8*b*. ¼ mile below head in 5 ft. of water.	0.0162	0.0027	0.0144	0.1854	0.00	0.60
8*c*. ½ mile below head in 7 ft. of water.	0.2100	0.2000	0.2042	3.1408	0.50	0.90
8*d*. ¾ mile from head in 9 ft. of water.	0.1707	0.2240	0.2227	3.8500	0.50	0.70
8*e*. 500 ft. above W. & N. R.R. in 12 ft. of water.	0.1943	0.2286	0.1838	2.7500	0.30	0.75
8*f*. 500 ft. below W. & N. R.R. in 12 ft. of water.	0.1103	0.0855	0.0790	1.3707	0.55	0.85

Series 9.

From Pasture Land about One and One-quarter Miles below West Boylston, on South Side of Railroad, which had never been cultivated. Samples taken from Surface to Twenty Inches below Surface. Samples dried at 100°C.

	Moisture. (Per Cent.)	Loss on Ignition. (Per Cent.)	Hydrogen. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
9a. Surface to 2 in. below, . . .	31.13	19.89	1.45	11.92	0.66	18.06
9b. 2 in. to 4 in. below, ...	29.17	11.52	0.66	5.32	0.48	11.08
9c. 4 in. to 7 in. below, ...	26.17	8.37	0.62	3.56	0.26	13.69
9d. 7 in. to 10 in. below, . . .	26.19	5.16	0.42	1.38	0.03	46.00
9e. 10 in. to 15 in. below, . . .	22.55	3.16	0.31	0.87	0.06	14.50
9f. 15 in. to 20 in. below, . . .	18.47	2.43	0.22	0.85	0.08	10.63

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.		Albuminoid Ammonia.		Oxygen Consumed.		Color.	
	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.	After 3 Days.	After 1 Week.
9a, ...	0.0096	0.0024	0.0530	0.1436	1.8330	2.1840	1.15	1.50
9b, ...	0.0056	0.0008	0.0254	0.0228	0.3003	0.4368	0.15	0.25
9c, ...	0.0040	0.0072	0.0188	0.0180	0.1170	0.1326	0.04	0.10
9d, ...	0.0016	0.0048	0.0066	0.0078	0.0429	0.0702	0.00	0.00
9e, ...	0.0096	0.0104	0.0066	0.0072	0.0156	0.0585	0.00	0.00
9f.	0.0048	0.0016	0.0050	0.0052	0.0195	0.0624	0.00	0.00

SERIES 10.

From Land recently cleared of Good-sized Timber and never cultivated, about Midway between Boylston and South Clinton, South Side of Valley. Samples taken from Surface to Two Feet Six Inches below. Dried at 100° C.

	Moisture. (Per Cent.)	Loss on Ignition. (Per Cent.)	Hydrogen. (Per Cent.)	Carbon. (Per Cent.)	Nitrogen. (Per Cent.)	Ratio. $\frac{c}{n}$
10*a*. Surface to 2 in. below, . . .	62.87	26.65	1.92	18.07	0.94	19.22
10*b*. 2 in. to 4 in. below, . . .	54.26	19.63	1.15	10.47	0.58	18.02
10*c*. 4 in. to 7 in. below, . . .	44.23	11.12	0.63	5.66	0.32	17.69
10*d*. 7 in. to 12 in. below, . . .	32.21	3.40	0.34	1.54	0.20	7.70
10*e*. 12 in. to 17 in. below, . . .	29.57	2.85	0.28	0.85	0.31	2.74
10*f*. 2 ft. 6 in. below, ...	17.60	0.52	0.05	0.04	0.11	0.36

Sanitary Analysis of Water with which the Soils had been treated as described.

[Parts per 100,000.]

	Free Ammonia.		Albuminoid Ammonia.		Oxygen Consumed.		Color.	
	After 2 Days.	After 1 Week.	After 2 Days.	After 1 Week.	After 2 Days.	After 1 Week.	After 2 Days.	After 1 Week.
10*a*, . . .	0.0560	0.0384	0.0902	0.1420	4.0560	6.8180	-	7.50
10*b*, . . .	0.0232	0.0224	0.0382	0.0320	0.8970	1.0267	0.80	4.50
10*c*, . . .	0.0064	0.0032	0.0264	0.0208	0.5144	0.6512	0.80	1.00
10*d*, . . .	0.0056	0.0024	0.0240	0.0254	0.2440	0.6448	0.30	1.20
10*e*, . . .	0.0056	0.0072	0.0738	0.0436	0.1584	1.3280	0.08	1.00
10*f*, . . .	0.0096	0.0024	0.0074	0.0066	0.0664	0.1008	0.03	0.12

EXPERIMENTS

UPON THE

PURIFICATION OF SEWAGE AND WATER

AT THE

LAWRENCE EXPERIMENT STATION,

DURING THE YEAR 1893.

EXPERIMENTS UPON THE PURIFICATION OF SEWAGE AND WATER AT THE LAWRENCE EXPERIMENT STATION.*

By George W. Fuller, Biologist in Charge.

The year 1893 is the sixth that the experimental work of the Lawrence Experiment Station has been continued. The work is carried on under the general supervision of Hiram F. Mills, A.M., C.E., a member of the State Board of Health. Mr. Allen Hazen, chemist, was in direct charge of the station until March 1, 1893, when he was given a leave of absence and accepted the position of chemist to the Department of Water Supply and Sewerage of the World's Columbian Exposition. The writer, who had previously been in charge of the biological department, succeeded Mr. Hazen in charge of the station. Mr. Harry W. Clark is chemist, and Mr. F. L. Fales has compiled the records and prepared the tables showing the results of the work. Messrs. W. R. Copeland and Louis Weinberg are assistant biologists and Mr. F. B. Forbes is assistant chemist. Professors T. M. Drown and W. T. Sedgwick of the Massachusetts Institute of Technology are, respectively, consulting chemist and biologist, having a general oversight of the chemical and biological investigations.

The year has been an important one in the history of the experimental sewage filters, in that the results of earlier investigations have been confirmed and additional knowledge has been obtained as to the management necessary to maintain the continuous efficiency of such filters.

The process of purification of sewage by intermittent filtration consists of intermingling the sewage in the pores of the filtering material with sufficient air, for a sufficient time, in the presence of micro-organisms which quickly establish themselves there.

* A full account of the work done at the Lawrence Experiment Station for the years 1888 and 1889 is contained in a Special Report of the State Board of Health upon the Purification of Sewage and Water, 1890. A similar account for the years 1890 and 1891 is contained in the Twenty-third Annual Report of the Board for the year 1891, and for the year 1892 in the Twenty-fourth Annual Report of the Board for that year.

Sewage filters resemble complex living organisms, in that ventilation and respiration must be maintained, otherwise their functions are interrupted and their lives as filters come to an end.

When sewage passes through a filter a portion of the insoluble matter or sludge is deposited upon or near the surface. The result, eventually, unless preventive measures are adopted, is a clogging at the surface, which, owing to interrupted ventilation, causes a deterioration in the quality of the effluent, and subsequently, owing to the increased capillary attraction and frictional resistance to the passage of sewage, a reduction in the quantitative efficiency of the filter. The amount of sludge in sewage varies, but, unless care is taken, any sewage will in time clog any ordinary filter. In the Annual Report of the Board for 1892 it was stated that when other conditions are the same, the clogging is proportional to the sludge carried in the applied sewage. It is of importance therefore to consider not only the filtering materials but also the applied sewage in order to learn its average strength and the limits in strength between which it varies.

Character of the Sewage.

The sewage used at the Experiment Station is pumped through a two and one-half inch pipe, 4,300 feet long, from a sewer which drains the streets, houses and stores of the most densely populated sections of the city of Lawrence.

Samples of Sewage for Analysis.

Samples of sewage have been regularly collected for analysis as follows: —

1. *Regular Sewage.* On at least four days in a week a gallon bottle has been filled from a large tank of sewage. While the sample was intended to be as far as possible a representative one, it necessarily represented accurately only a small fraction of the total amount of sewage used; and there is also considerable difficulty in mixing several hundred gallons of sewage so as to get a sample with its proper share of suspended matter.

2. *Average Sewage.* On one day each week (Tuesday), a sample has been taken by collecting directly from the pump (without allowing any opportunity for sedimentation), quantities of sewage propor-

tional to the amount of each lot of sewage pumped during the day. The average results from numerous samples collected in this manner give satisfactorily the average composition of all sewage applied to the filters.

3. *Sewage for Filters Nos. 1, 6 and 9A.* In order to learn the variations in strength of sewage at different times of the day and to obtain more accurate data upon the storage of organic matter in the filters there have been collected weekly three mixed samples representing each dose applied during the week to Filters Nos. 1, 6 and 9A, respectively. In order to keep the samples for one week without putrefaction and decomposition, a small amount of mercuric acetate was placed in the bottle.

Monthly Averages of Analyses of Regular Sewage Samples.

[Parts per 100,000.]

MONTH—1898.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Albuminoid Ammonia. Insoluble.	Chlorine.	Oxygen Consumed.*	Fats.	Bacteria per Cubic Centimeter.
January,	2.44	.83	.41	.42	8.22	4.98	3.9	1,104,000
February,	2.41	.68	.37	.31	6.93	4.33	2.4	985,000
March,	2.02	.64	.34	.30	6.05	4.15	3.3	907,000
April,	2.42	.83	.35	.48	6.57	4.16	1.7	1,109,000
May,	2.23	.51	.30	.21	6.58	2.82	2.5	755,000
June,	2.54	.53	.28	.25	11.37	2.68	-	774,000
July,	3.02	.63	.32	.31	8.71	2.72	-	854,000
August,	2.82	.45	.22	.23	10.66	2.53	-	965,000
September,	2.75	.47	.22	.25	9.92	2.44	-	636,000
October,	3.07	.61	.25	.36	10.72	2.92	-	1,125,000
November,	3.28	.71	.29	.42	10.79	4.29	-	1,000,000
December,	3.16	.70	.33	.37	6.29	3.51	-	861,000
Averages,	2.68	.63	.31	.32	8.57	3.45	-	923,000

* In all of the Lawrence analyses the oxygen consumed has been determined after boiling two minutes.

The above analyses represent four samples each week taken from one of the sewage tanks, usually in the morning, and the results are directly comparable with the analyses published for previous years.

Monthly Averages of Analyses of Average Sewage Samples.

[Parts per 100,000.]

Month—1893.	Free Ammonia.	Albuminoid Ammonia. Total.	Albuminoid Ammonia. Soluble.	Albuminoid Ammonia. Insoluble.	Chlorine.	Oxygen Consumed.	Fats.
January,	2.41	.79	.37	.42	6.69	4.46	-
February,	2.36	.75	.43	.32	5.78	4.10	-
March,	1.86	.62	.38	.24	4.33	3.50	-
April,	2.39	.70	.33	.37	5.56	3.55	-
May,	2.39	.65	.30	.35	6.28	2.90	-
June,	2.86	.63	.32	.31	11.89	3.02	-
July,	3.41	.65	.29	.36	9.05	2.95	4.1
August,	3.70	.65	.28	.37	7.88	3.27	3.0
September,	3.80	.70	.31	.39	6.72	3.42	5.9
October,	3.77	.85	.38	.47	6.80	3.88	5.5
November,	4.05	.95	.48	.47	7.75	4.55	5.9
December,	3.85	.93	.41	.52	7.05	4.02	5.7
Averages,	3.07	.74	.36	.38	7.15	3.63	-

The above analyses represent average samples of all the sewage pumped during the day for each Tuesday of the year.

Monthly Averages of Mixed Samples, representing all of the Sewage applied to Filters Nos. 1, 6 and 9 A.

[Parts per 100,000.]

Month—1893.	Free Ammonia. Filter No. 1.	Free Ammonia. Filter No. 6.	Free Ammonia. Filter No. 9 A.	Albuminoid Ammonia. Filter No. 1.	Albuminoid Ammonia. Filter No. 6.	Albuminoid Ammonia. Filter No. 9 A.	Oxygen Consumed. Filter No. 1.	Oxygen Consumed. Filter No. 6.	Oxygen Consumed. Filter No. 9 A.	Chlorine. Filter No. 1.	Chlorine. Filter No. 6.	Chlorine. Filter No. 9 A.	Fats. Filter No. 1.
January,	1.50	2.47	1.55	.57	.76	.52	3.40	4.45	3.30	4.48	7.79	4.77	4.6
February,	2.10	2.19	1.90	.64	.81	.59	3.40	4.92	3.67	9.41	5.94	6.04	2.0
March,	1.85	2.34	1.96	.46	.61	.48	4.00	4.50	4.00	5.72	5.91	7.14	3.3
April,	1.94	2.54	2.06	.57	.73	.63	2.82	3.72	3.02	6.02	5.58	5.67	2.4
May,	2.42	2.39	2.47	.61	.43	.62	2.72	3.07	3.00	6.14	6.26	5.97	4.6
June,	2.71	2.58	2.84	.68	.64	.61	3.02	3.70	3.20	8.17	7.45	9.70	3.4
July,	3.31	2.76	3.52	.72	.73	.88	3.22	3.52	3.82	9.98	12.50	8.83	3.7
August,	2.79	3.40	3.15	.66	.57	.51	3.30	3.97	2.87	10.03	9.13	9.54	5.9
September,	3.56	3.91	3.35	.77	.77	.69	3.96	3.84	3.38	8.06	7.29	7.44	7.5
October,	3.79	4.29	4.26	.82	.89	.87	4.37	7.37	4.22	7.59	7.46	10.91	6.6
November,	3.97	3.84	4.26	.88	.79	1.00	4.72	5.25	5.05	7.43	6.88	6.56	6.8
December,	3.04	3.75	3.22	.82	.95	.88	4.40	5.57	3.92	6.75	7.45	6.08	3.3
Averages,	2.75	3.04	2.88	.68	.72	.69	3.61	4.49	3.62	7.81	7.47	7.39	4.5

With regard to the comparison of the results with each other it is to be mentioned that the sewage for Filter No. 1 was all pumped late in the afternoon during the cold months, December to April, inclusive; in May and June it was pumped early in the morning, and during the rest of the year part in the early morning and the

remainder in the afternoon. Sewage for Filter No. 6 was regularly pumped in the middle of the day. In the case of Filter No. 9 A the sewage was pumped late in the afternoon during the cold months, December to April, inclusive, and early in the morning during the remainder of the year. The results are comparable with corresponding results obtained in 1892.

Monthly Averages of Supernatant Liquid from Sewage settled with Alum for Filters Nos. 19 and 32.

[Parts per 100,000.]

MONTH—1893.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.				
January,*	2.15	.38	.27	.11	5.40	2.70	-	260,000
February,	1.97	.26	.19	.07	6.56	2.72	.2	77,500
March,	1.91	.28	.21	.07	6.43	2.32	.7	81,000
April,	2.24	.27	.22	.05	5.57	1.83	.5	20,000
May,	2.29	.28	.18	.10	5.99	1.52	1.3	63,000
June,	2.34	.32	.20	.12	9.86	1.62	-	460,000
July,	3.27	.34	.23	.11	7.66	1.60	1.5	230,000
August,	2.48	.24	.17	.07	7.73	1.36	.8	50,000
September,	2.80	.27	.20	.07	11.73	1.50	1.1	63,000
October,	2.64	.27	.18	.09	5.98	1.47	3.3	315,000
November,	3.04	.32	.24	.08	13.72	2.06	1.7	37,000
December,	3.29	.34	.24	.10	5.74	1.92	.9	187,000
Averages,	2.54	.30	.21	.09	8.10	1.88	1.2	145,000

* The sewage was not treated in this manner January 1 to 20; the results for this month given in the table represent the analyses of January 21 to 31.

The above analyses represent the supernatant liquid after the sewage represented by the regular samples had been treated with alum, in the proportion of 1,000 pounds of alum to 1,000,000 gallons of sewage, and allowed to settle for four hours. These results show that 52.4 per cent. of the total albuminoid ammonia and 84.3 per cent. of the bacteria were removed. The high numbers of bacteria in June and July appeared to be due to a growth of bacteria on the sides of the barrels where some organic matter had accumulated. The removal of this organic matter from time to time caused the number of bacteria in the supernatant liquid to become normal.

Monthly Averages of Supernatant Liquid from Settled Sewage for Filter No. 13 A.

[Parts per 100,000.]

MONTH — 1893.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Total.	Soluble.	Insoluble.			
October,	2.70	.43	.25	.18	6.22	2.32	344,000
November,	3.13	.60	.32	.28	18.73	3.54	398,000
December,	3.25	.60	.30	.30	5.96	3.12	356,000
Averages,	3.03	.54	.29	.25	10.31	2.99	366,000

The analyses above represent the supernatant liquid after the sewage represented by the regular sample had been allowed to settle for four hours. These results, when compared with those of the regular samples of sewage, taken on the same days, show a removal of 18.2 per cent. of the total albuminoid ammonia and 12.0 per cent. of the bacteria by sedimentation.

Comparison of the Strength of the Sewage.

Bringing together for comparison the average results of the several series of sewage samples, we have: —

[Parts per 100,000.]

	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.
		Total.	Soluble.	Insoluble.		
Regular,	2.68	.63	.31	.32	6.57	3.45
Average,	3.07	.74	.36	.38	7.15	3.63
For Filter No. 1,	2.75	.68	.31*	.37	7.81	3.61
For Filter No. 6,	3.04	.72	.31*	.41	7.47	4.49
For Filter No. 9A,	2.88	.69	.31*	.38	7.39	3.62

* Estimated as equal to that in the regular sample.

It will be seen that the average sewage for the day was the most concentrated, although only a little stronger than the sewage applied to Filters Nos. 1, 6 and 9A. The regular sewage was the most dilute of all, as was the case in 1892.

Investigations are under way to show the relation of the strength of the sewage as drawn at the Experiment Station to that of the original sewage in the Lawrence Street sewer. The results of two such series of analyses are given in the table below. On January 16 and 17, 1894, when the first series was collected, the weather was

clear and cold, and probably very little surface water entered the sewer. The second series was taken during a storm. The amount of precipitation (rain and melted snow) was 1.47 inches, the greater part of which was snow; considerable rain fell during the night of January 30, however, and found its way to the sewer. In the second series estimates of the quantity of sewage flowing in the sewer were made from observations of the depth of sewage in the sewer.

Results of Analyses of Hourly Samples of Sewage from the Lawrence Street Sewer.

[Parts per 100,000.]

	January 16 and 17.							January 30 and 31.										
		Ammonia.						Temperature. Degrees F.			Ammonia.							
			Albuminoid.									Albuminoid.						
Hour.	Temperature. Degrees F.	Free.	Total.	Insoluble.	Chlorine.	Oxygen Consumed.	Fats.	Sewage.	Air.	Rate. Million Gals. per 24 Hours.	Free.	Total.	Insoluble.	Chlorine.	Oxygen Consumed.	Fats.	Bacteria per Cubic Centimeter.
6 P.M.	42.	1.20	.56	.25	6.15	6.70	.7	–	34.5	1.1	[illegible]	.58	.18	4.70	3.00	[illegible]	680,000
7 "	42.5	1.20	.42	.12	3.80	3.70	4.1	[illegible]	34.	.9	[illegible]	.60	.16	5.17	3.10	2.3	418,000
8 "	43.	1.85	.60	.16	4.[illegible]	1.80	2.4	43.	33.	[illegible]	1.70	.58	.27	4.29	[illegible]	2.8	648,000
9 "	44.	1.85	.56	.11	3.80	2.60	1.9	44.	[illegible]	1.8	[illegible]	.67	[illegible]	3.78	2.20	1.6	616,000
10 "	44.	1.60	.46	.16	4.00	3.30	2.1	44.	[illegible]	1.5	1.96	.64	.35	[illegible]	[illegible]	3.4	504,000
11 "	43.	1.15	.26	.07	3.50	1.80	.8	43.	34.	.9	1.75	.43	.17	[illegible]	1.70	1.4	188,000
12 "	44.	1.05	[illegible]	.04	2.80	1.60	[illegible]	[illegible]	33.5	.9	1.26	.26	[illegible]	3.27	[illegible]	1.0	[illegible]
1 A.M.	44.	.75	.16	[illegible]	2.80	1.20	1.7	42.	[illegible]	1.1	[illegible]	.18	.04	[illegible]	[illegible]	2.1	441,000
2 "			.17	.04	2.10	1.00	1.4	41.	34.5	1.6	.45	.15	.02	21.00	.90	.4	284,000
3 "			.14	.02	2.10	.90	4.6	40.	[illegible]	1.8	.46	.18	[illegible]	3.77	.90	1.2	164,000
4 "			.17	.04	2.10	.70	[illegible]	40.	35.5	2.1	.56	[illegible]	.04	2.61	.90	1.6	283,000
5 "			.12	.01	2.10	.70	[illegible]	39.5	[illegible]	2.4	[illegible]	.14	[illegible]	[illegible]	1.00	2.0	138,000
6 "			.28	.04	3.00	1.60	6.9	40.	31.	1.8	1.04	[illegible]	.07	4.06	[illegible]	.4	[illegible]
7 "			.40	.16	3.45	1.90	4.8	44.	31.	1.8	1.28	.40	.12	3.68	[illegible]	.5	[illegible]
8 "			.82	.36	4.75	4.40	6.3	45.	[illegible]	2.4	2.25	[illegible]	.82	12.62	[illegible]	2.2	1,130,000
9 "			1.14	.64	5.50	5.60	4.3	46.	[illegible]	2.4	1.80	[illegible]	[illegible]	[illegible]	3.40	2.7	668,000
10 "			1.49	.93	6.80	6.40	11.0	46.	[illegible]	1.8	1.65	.66	.18	4.75	3.60	2.5	636,000
11 "			1.01	[illegible]	6.02	5.00	19.0	44.5	30.5	2.1	[illegible]	.64	.11	4.15	3.40	[illegible]	412,000
12 M.			1.19	.67	6.22	5.00	16.9	[illegible]	32.5	2.6	1.96	.64	.14	4.63	3.20	3.9	649,000
1 P.M.			.73	[illegible]	6.62	5.00	11.2	46.	29.5	[illegible]	1.75	.50	.21	4.31	3.40	2.6	406,000
2 "			.96	.36	5.22	5.40	16.6	45.	[illegible]	2.4	[illegible]	.70	[illegible]	5.20	5.50	3.9	580,000
3 "			.78	.29	5.02	4.70	13.4	[illegible]	[illegible]	1.8	[illegible]	.64	.21	3.99	3.70	3.8	[illegible]
4 "			.60	.08	4.64	4.20	6.6	47.	27.	2.1	1.80	.56	.10	3.46	3.30	1.2	[illegible]
5 "			.64	.14	4.06	4.50	9.4	–	–	–	–	–	–	–	–	–	–

From the data obtained in the second series there was calculated a representative analysis of all the sewage which passed through the sewer during this period of twenty-four hours. In the following table this representative analysis of all the sewage flowing for twenty-four hours in the sewer is compared with the average analysis of all the sewage pumped at the Experiment Station during this period (7 A.M. to 5 P.M. January 31).

[Parts per 100,000.]

January 30 and 31, 1894.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.
		Total.	Soluble.	Insoluble.		
Lawrence Street sewer, . .	1.40	.54	.36	.18	5.56	2.87
Experiment station, . . .	2.70	.73	.49	.24	5.72	5.50

These results indicate that the average sewage applied to the experimental filters during this period was considerably stronger than the average original sewage flowing in the sewer. Whether or not the difference is always so marked will require further experiments to determine. It is instructive to compare the analyses of the sewage in the two series, and also the variations at different times during the day in each series.

It has been found that the sewage in the Lawrence Street sewer contains considerable dissolved oxygen, while the sewage as pumped at the Station contains none. Experiments are in progress to compare the results of purification by filtration of fresh sewage from the Lawrence Street sewer and of sewage as pumped at the Station, both with and without aeration.

Since clogging and consequent interference with ventilation are the chief factors to be considered in studying the continuous efficiency of filters, it is of importance to know the strength of the sewage which has been treated and the amount of sludge which it contained. In the table below are given averages of analyses for the year 1893 of the sewage applied to the experimental filters at Lawrence, and of that of the cities and towns in Massachusetts which purify their sewage by intermittent filtration.

Average of Analyses of the Sewage applied to the Experimental Filters at Lawrence, and of that applied to the Filters used by certain Cities and Towns.

[Parts per 100,000.]

Sewage.	Free Ammonia.	Albuminoid Ammonia.			Chlorine.	Oxygen Consumed.
		Total.	Soluble.	Insoluble.		
Lawrence,	3.07	.74	.38	.36	7.15	3.63
Framingham,	1.88	.38	.19	.19	4.93	5.14
Marlborough,	2.08	.62	.38	.24	7.35	6.29
Gardner,	1.80	.45	.21	.24	3.11	3.94
Westborough,*	1.07	.19	.05	.14	2.27	2.72

* Two samples from Westborough were analyzed; the other results (except Lawrence) are averages of semi-monthly analyses.

This table shows that the sewage applied to the experimental filters contains more sludge than the sewage of the other places, and consequently the experimental filters require more attention to prevent clogging than do the several large filters in actual service which receive more dilute sewage.

Average Purification of Sewage by the Several Filters in 1893.

In the table below are given the average percentages of removal of organic matter (albuminoid ammonia) and of bacteria by the several filters to which ordinary sewage was applied. For the construction and details of operation and results see pages 429–452.

Average Per Cent. of Albuminoid Ammonia and of Bacteria removed from Sewage by the Several Filters, with Average Rates of Filtration, 1893.

Number of Filter.	Average Rate of Filtration. (Gallons per Acre Daily for Six Days in a Week.)	Per Cent. of Albuminoid Ammonia Removed.	Per Cent. of Bacteria Removed.	Number of Filter.	Average Rate of Filtration. (Gallons per Acre Daily for Six Days in a Week.)	Per Cent. of Albuminoid Ammonia Removed.	Per Cent. of Bacteria Removed.
1,	106,000	86	89	11 A,	58,900	89	95
2,	40,500	97	99.8	13,	154,100	91	95
3 A,	56,300	91	99.9	14,	174,000	95	96
4,	32,300	96	99.9	15 B,	404,700	77	77
5 A,	119,000	82	77	16 B,	415,200	75	81
6,	73,800	91	99	17 A,	58,500	95	99.9
7,	32,000	92	99.8	30,	55,100	90	97
9 A,	111,700	92	99	31,	55,100	96	99.9

These results show that with most of the filters the removal of organic matter was over 90 per cent., while five of them removed 95 per cent. or more. It is to be stated, however, that both the quantitative and qualitative efficiency were in many cases below the normal during the early part of the year. This was owing to the fact that for some time previous the filters had been operated in a manner believed to be unlikely to produce the best results, but tried for the sake of learning the effect of certain methods of operation. The methods of treatment by which the filters resumed their former ability to purify sewage are described and discussed on pages 412–421.

Permanency of Sewage Filters.

In studying the subject of purification of sewage by filtration a matter of vital importance is the question of the permanency of filters. It is well known that with filters of suitable material sewage may be purified at a rate of more than 100,000 gallons per acre daily, with a removal of over 90 per cent. of the organic matter. It is also known that some of the organic matter of the sewage is stored at and near the surface of the filter, and that under some circumstances there is a certain amount of storage for some distance below the surface. It has been learned that in the case of filters which have regularly filtered sewage at a comparatively high rate it is eventually necessary to spade up the surface in a manner corresponding to ploughing, and later to remove the clogged surface layers and replace them with fresh material. We shall consider the treatment of the upper layers of a sewage filter, say the upper six inches, under the heading of management of filters necessary for their successful operation, and regard the permanency of the filters as the ability of the main body of the sand, below the upper six inches, under proper treatment, to purify sewage for an indefinite time.

In the Annual Report for 1891 it was shown that the storage of organic matter in the filters at that time was steadily increasing. This conclusion was drawn from repeated determinations of nitrogen stored in the sand. During the past two years numerous examinations have been made, but, owing to the unequal distribution of sewage through the material caused by trenching and in other ways, it was found to be practically impossible to obtain results which represent correctly the entire filter. Accordingly the calculations of the quantities of organic matter stored within the filter have been made after another method in 1893. The results of repeated determinations of

nitrogen stored in the sand during the earlier years of the experiments indicated that 30 per cent. of the applied nitrogen was not to be found either in the sand or in the effluent. It probably disappeared in the atmosphere; possibly as nitrogen gas. To the nitrogen found in the average analyses of representative samples of each effluent has been added 30 per cent. of the amount in each case, and the difference between this corrected quantity in the effluent and the quantity of nitrogen in the applied sewage has been taken to represent the amount of nitrogen stored in the filters. In the table below are given the percentages which the nitrogen in the effluents, calculated as described above from the averages of representative analyses, formed of the nitrogen in the applied sewage, by months. The sign minus, of course, indicates a removal of stored nitrogen.

Per Cent. of Applied Nitrogen that was stored in the Sewage Filters, in 1893.

Number of Filter.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Averages.
1, . . .	—56	5	—11	14	—21	—31	—37	—41	3	22	28	6	—10
2, . . .	36	77	80	12	—125	—86	—36	1	2	—6	17	11	—1.5
3 A, . . .	33	—2	—2	9	—5	—59	—17	—14	-	-	-	-	—7
4, . . .	27	62	79	55	49	57	51	15	25	17	31	49	43
5 A, . . .	7	1	—18	—5	—29	25	29	5	25	25	20	5	7.5
6, . . .	44	19	—29	—33	—80	—66	—11	15	53	1	22	27	—3
7, . . .	42	19	0	—7	-	-	—157	46	27	28	17	22	3
9 A, . . .	—10	1	—2	—24	—42	—40	10	3	20	22	33	—1	—2.5
11 A, . . .	24	11	—5	45	27	60	69	60	—38	12	4	27	25
12 A, . . .	—6	—2	—1	4	—12	4	32	15	21	28	24	26	11
13, . . .	-	-	-	0	—18	—49	—9	3	24	-	-	-	—8
13 A, . . .	-	-	-	-	-	-	-	-	-	0	13	—10	1
14, . . .	29	—13	—51	—30	—84	—88	—43	—1	13	38	67	—4	—14
15 B, . . .	57	58	23	28	18	13	16	19	22	22	42	34	28
16 B, . . .	32	28	14	28	12	27	10	26	29	43	40	36	27
17 A, . . .	11	19	—8	—8	—59	—111	—54	—8	47	26	—28	13	—18
19, . . .	22	—34	—49	—26	—41	—17	—38	1	—16	—26	—41	—19	—24
20, . . .	16	2	—34	—11	—54	- 90	- 98	—27	—3	—8	23	8	—23
21, . . .	—1	5	—11	1	—61	—76	—61	—46	—1	—2	22	28	—17
22, . . .	22	8	—34	—18	—34	—6	50	44	48	8	—21	—3	5

Summary and Conclusions.

1. It will be seen that the only filters in which there was a continued storage of nitrogen were Nos. 4, 15 B and 16 B. These filters represent the extreme limits in the size of materials and the results are explained by the fact that there was an insufficient amount of air for the complete oxidation and nitrification of the applied sewage. From this it follows that the permanency of sewage filters is independent of the size of material, but is directly dependent upon the treatment which they receive.

2. The removal of large amounts of stored organic matter in the spring and early summer months, under favorable conditions, is one of the most marked characteristics of sewage purification by intermittent filtration.

3. It will be noticed that in several cases the storage of nitrogen during the winter months was very slight, while in some instances there was a removal. This is not apparent from the degree of purification of the corresponding effluents, in which the free ammonia was very high, and this seeming discrepancy is explained by the fact that while freezing winter weather interferes with nitrification it does not seriously affect the oxidation of carbonaceous matter to free ammonia.

4. The average results from all the filters, some of which have been in operation regularly for six years, indicate that there was practically no more nitrogen stored in the filters at the end than at the beginning of the year. From this it appears that, with the main body of the sand the same, sewage filters may continue to purify sewage for an indefinite time provided they receive proper treatment to insure sufficient ventilation for the oxidation and nitrification of the applied sewage.

Management of Filters to Secure Continuous Efficiency.

An outline of the results obtained by different methods for the conservation of the efficiency of sewage filters is as follows: —

Systematic Raking followed by Scraping.

In 1890 it was learned that the interruption of the ventilation of a filter, owing to clogging by the stored organic matter of the sludge at the surface, was prevented, to a great extent, by a systematic weekly raking to a depth of about one inch. Eventually the storage

of sludge in the material disturbed by the weekly raking is so great that ventilation is no longer afforded by this means. It is then necessary, in order to insure the continued efficiency of the filter, to present cleaner material at the surface; and one of the ways by which this may be accomplished is by removing the clogged material by scraping and replacing it with fresh material. (See page 420 with regard to the addition of new material.)

Filter No. 1. — This filter is one two-hundredths of an acre in area and contains 63 inches in depth of sand of an effective size * of 0.48 millimeter. On June 2, 1892, there were removed from the surface 5 inches of clogged material which had been more or less disturbed and mixed together by trenching. This was four years and five months after the filter was first put in operation. No new material was added at this time. The efficiency of the filter was satisfactory during the following months until freezing weather set in. The quality of the effluent improved during March and April, but the surface soon became clogged so that the sewage failed to disappear from the surface in twenty-four hours. On May 5, 1893, a layer of clogged sand, 4 inches in depth, was removed by scraping and new material added to restore the filter to its original depth of 63 inches. The total depth removed in the five years and four months up to this date was 9 inches, or 7.9 cubic yards per million gallons of sewage filtered. The 4-inch layer removed May 5, 1893, was equivalent to 15 cubic yards per million gallons filtered since June 2, 1892. Very good results followed this treatment. The rate of filtration up to July 10 was 120,000 gallons per acre daily for six days in a week; July 11 to August 31, 60,000 gallons; September 1 to 17, 80,000 gallons; September 18 to December 22, 120,000 gallons; and December 23 to 31, 60,000 gallons. During the six months, May to October, inclusive, the average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage was 93.2 and 95.5 per cent., respectively, while the nitrification was very high. The averages of the analyses of the effluent showed that it contained 3.16 parts per 100,000 of nitrogen as nitrates, which indicates a removal of some of the organic matter stored in the sand.

Filter No. 6. — This filter contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter. The surface has been raked regularly once a week since Jan. 1, 1891.

* The "effective size" means that ten per cent. by weight of the sand grains are finer than the diameter given.

On March 29, 1892, 2 inches of clogged material were scraped from the surface and replaced with new material. The filter was spaded over in layers to a depth of 2 feet on May 19, 1892, to break up stratification. The surface became clogged again Sept. 25, 1893, when 2 inches were again scraped off. The total depth of 4 inches removed up to this date is equivalent to 5.8 cubic yards of sand per million gallons of sewage filtered; the 2 inches removed Sept. 25, 1893, are equivalent to 9.7 cubic yards per million gallons filtered since May 19, 1892. During this latter period the average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage was 94.2 and 99.3 per cent., respectively. The effluent contained, on an average, 2.83 parts per 100,000 of nitrogen as nitrates. The average rate of filtration was 62,400 gallons per acre daily for six days in a week. From September 1 to December 21 the rate was 90,000 gallons, and from December 22 to 31, 50,000 gallons.

Systematic Scraping when Necessary, without Raking.

Filter No. 9 A.—This filter is 60 inches in depth and contains sand of an effective size of 0.17 millimeter. The upper 6 inches were removed, and the rest of the material taken out and replaced dry May 20, 1892, in order to break up stratification. The surface was raked weekly until July 20, 1892, but since that time it has not been raked, but was scraped whenever the surface became sufficiently clogged to prevent the passage of sewage through the filter. The filter was scraped eleven times from May 20, 1892, to Nov. 16, 1893, and on the latter date the applied sewage failed to disappear just after scraping, indicating a clogging beneath the surface. The filter was restored to its original depth by the addition of new material after scraping on March 14 and Sept. 25, 1893. The total depth removed was 5.54 inches, which is equivalent to 13.8 cubic yards per million gallons of sewage filtered during the period. The rate of filtration, 120,000 gallons per acre daily, for six days in a week, is very high for this material. The average removal of organic matter (albuminoid ammonia) and bacteria from the sewage for the entire period was 94.1 and 98.3 per cent. respectively. The nitrogen as nitrates averaged 2.03 parts per 100,000 in the effluent.

A decided objection to this method of treatment is that the frequent interruption in ventilation causes a temporary decrease in nitrification and an increase in the storage of organic matter. With

long intervals between scrapings this would not be serious; but, as in the case of Filter No. 9 A, there may eventually come a time when the scrapings are so frequent that nitrification does not get fully re-established before clogging occurs again.

It was necessary to scrape, after November 16, 4½ inches, before the sewage would disappear readily. As the removed sand did not contain sufficient stored organic matter to explain this clogging, its final interpretation must be postponed until something is known of its subsequent history. It is to be mentioned, however, that compactness of the material seemed to be an important feature.

Systematic Scraping at Regular Intervals, without Raking.

No experiments upon this point have been made as yet at the Experiment Station, but the sewage filters at Gardner have been treated in this manner for more than two years. The sand in these filters has an effective size of 0.10 to 0.24 millimeter, and the sewage is applied with a two-day interval of rest at an average rate of about 60,000 gallons per acre daily. About one-eighth inch of scum and clogged sand is removed once in ten days to two weeks. After scraping off the stored sludge the sand is raked to a depth of 1 to 1½ inches to loosen the material. This treatment appears to be very satisfactory.

Systematic Raking followed by Ploughing.

Upon the application of sewage to filters of coarse sand the sludge passes deeper into the material than in the case of filters of fine sand; eventually a clogging occurs at a point just beneath that reached in the weekly raking (1 inch deep). Under these circumstances the surfaces have been spaded over in a manner corresponding to ploughing.

Filter No 3 A.—This filter contains 30 inches in depth of coarse sand above 30 inches of fine sand. The effective sizes are 0.48 and 0.08 millimeter, respectively. The surface was spaded over 6 inches deep Oct. 19, 1892, and, with the aid of weekly raking, the applied sewage disappeared promptly until August, 1893, when the filter became clogged again. The surface was spaded over 6 inches deep August 14, after which the applied dose of sewage, equivalent to 60,000 gallons per acre daily for six days in a week, disappeared promptly, and the quality of the effluent steadily improved up to September 1, when the experiment was discontinued.

Filter No. 5 A.—This filter contains 63 inches in depth of screened gravel of an effective size of 1.40 millimeters. Clogging beneath the surface became apparent June 12, 1893, and was relieved by raking 2 inches deep. The rate of filtration was 120,000 gallons per acre daily for six days in a week. Sub-surface clogging appeared again September 15, when the surface was spaded over 6 inches deep. On October 30 the rate was increased to 160,000 gallons per acre, and clogging began to appear again the first of December.

Under this method of treatment it would be necessary, if a high rate of filtration were maintained, to resort eventually to scraping, as was the case with Filter No. 5 A in December.

Trenching.

Filter No. 2.—This filter contains 60 inches in depth of very fine sand of an effective size of 0.08 millimeter. In the winter of 1892–93 the surface of the filter became very badly clogged, and on March 2 there were dug two circular trenches, each one foot wide and two feet deep, one and a half and five feet, respectively, from the edge of the filter. These trenches were filled to within three inches of the top with sand of an effective size of 0.19 millimeter. The prescribed dose of 40,000 gallons per acre daily for six days in a week was then taken without difficulty and the quality of the effluent steadily improved. On September 1 the dose was increased to 60,000 gallons. During October the trenches gradually showed the effect of clogging, and finally were unable to take the prescribed dose. At the same time the free ammonia in the effluent began to increase. On October 30 the upper two inches of sand in the trenches were removed and replaced with fresh material. This afforded but little relief, owing to a clogging further down in the filter, as is explained beyond. The sand removed was equivalent to 7.9 cubic yards per million gallons of sewage filtered since March 2, 1893, and contained 118 parts per 100,000 of albuminoid ammonia. The average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage during this time was 95.7 and 99.7 per cent., respectively. The effluent contained on an average 2.86 parts per 100,000 of nitrogen as nitrates, which indicates a removal of some of the organic matter stored in the sand during the winter months. The average rate of filtration was 43,000 gallons per acre daily for six days in a week.

The trenches in this filter probably doubled the quantity of sewage which could be successfully treated, and moreover caused a marked improvement in the quality of the effluent.

Construction of Trenches.

When coarse sand is placed in trenches dug in finer sand some of the sludge of the applied sewage in time works down to the fine sand at the junction, where the gradually increasing storage causes an increase in the capillary attraction, and eventually so large a proportion of the space between the sand grains is constantly filled with water that the ventilation is seriously impaired and the frictional resistance is so great that both the qualitative and quantitative efficiency of the filter are crippled.

Filter No. 2 became clogged in this manner, and on Dec. 2, 1893, the coarse sand was removed from the trenches and also two and a half inches of the fine sand beneath it. After raking the sides and the bottom of the trenches, a layer five inches in depth of thoroughly mixed coarse and fine sand, with the coarse gradually decreasing downward, was put back, with a view to preventing the occurrence of any sharply dividing line in the difference in capillary attraction. As far as can be judged at the time of writing the effect upon the filter was very beneficial. In the case of deep trenches, where much of the sewage passes through the sides, it would probably be desirable to treat the sides in a somewhat similar manner.

Some experiments have been made, showing comparisons of the capillarity and other physical characteristics of coarse and fine sand and several mixtures of the two. The materials (Nos. 1 and 2 sands) were dried and thoroughly mixed. In the table below are given the mechanical composition, effective size, uniformity coefficient, per cent. of open space and specific gravity, as well as the capillarity in each case. The capillarity was determined by finding the amount of water held in the pores of the sand after draining twenty-four hours, and it is instructive to note that the mixtures of one part coarse and three parts fine and equal parts of coarse and fine held more water than the fine alone, while the other mixture held only a little less.

Mechanical Composition of Sands.

Diameter in Millimeters.	Per Cent.				
	Coarse.	Fine.	One part Coarse, three Fine.	Equal parts, Coarse and Fine.	Three parts Coarse and one Fine.
Finer than 5.9, ...	100.	-	-	-	-
" 3.9, ...	98.	-	100.	100.	100.
" 2.0, ...	93.	-	99.	94.	90.
" .93, ...	82.0	-	89.	75.	61.
" .46, ...	8.0	100.	72.	54.	30.
" .32, ...	3.3	98.	69.	51.	25.
" .18, ...	.9	88.	62.	46.	22.
" .10, ...	.4	24.	15.	13.	6.
" .08, ...	-	10.	6.	5.	3.
" .04, ...	-	2.	2.	1.	-

Physical Characteristics.

	Effective Size. Millimeter.	Uniformity Coefficient.	Per Cent. Open Space.	Specific Gravity.
Coarse, ...	0.48	2.5	40.	1.64
Fine, ...	0.08	2.0	44.	1.50
One part coarse and three fine, ...	0.09	2.1	37.	1.68
Equal parts, coarse and fine, ...	0.10	3.7	34.	1.74
Three parts coarse and one fine, ...	0.13	6.6	35.	1.73

Per Cent. of Total Open Space in each Foot occupied by Water after being filled and then drained for Twenty-four Hours.

	Coarse.	Fine.	One Part Coarse, Three Parts Fine.	Equal Parts, Coarse and Fine.	Three Parts Coarse, One Part Fine.
Upper foot, ...	15	39	38	38	26
Second foot, ...	15	45	51	56	32
Third foot, ...	16	64	68	71	44
Fourth foot, ...	16	84	97	88	68
Fifth foot, ...	18	100	100	100	88

Resting.

Filter No. 4. — This filter contains 60 inches in depth of fine river silt of an effective size of 0.04 millimeter and has received sewage since June 24, 1889, in a trench of coarse mortar sand. This trench covers one-third the area of the filter, is 14 inches deep, and is filled to within 3 inches of the top with the coarse sand. In the winter of 1892–93 the trench became clogged and unable to take the dose of 40,000 gallons per acre daily for six days in a week. On March 6 the upper 2 inches of sand in the trench, containing 75 parts per 100,000 of albuminoid ammonia, were removed. This was a total removal of 3½ inches since June 24, 1889, and equivalent to 3.79 cubic yards per million gallons; the 2 inches removed March 6, 1893, were equivalent to 9.3 cubic yards per million gallons filtered since May 9, 1892, the date of the first removal. This did not afford relief, and the coarse sand was taken out of the trench, the upper half inch of the fine sand beneath it was removed and the coarse sand replaced. Clogging again occurred in May, and a new trench was constructed June 2, the old one being allowed to rest. Analyses of the sand showed that there was a reduction of 39 per cent., from June 2 to August 16, of the albuminoid ammonia stored in the trench. Another analysis on October 30 showed no farther reduction, but the sewage was applied to the original trench from that date throughout the year without difficulty. The rate of filtration since June 2 has been 30,000 gallons per acre daily for six days in a week. The average removal of organic matter (albuminoid ammonia) and bacteria from the applied sewage, May, 1892, to October, 1893, inclusive, was 92 9 and 99.993 per cent., respectively. For November and December, 1893, these figures became 98.2 and 99.999, respectively. The nitrogen as nitrates in the effluent averaged 1.09 and 2.14 parts per 100,000, respectively, during the two periods.

The construction of double trenches, allowing each to work and rest alternately, in periods, is of much practical value; and, moreover, the removal of stored organic matter by simple resting indicates that this inexpensive method is worthy of careful consideration in the treatment of large areas of clogged filtering material.

Addition of New Material.

For some time it has been known that the passage of sewage through sand increases the amount of stored organic matter, which forms a sticky coating around the sand grains and thereby increases the capillary attraction. Accordingly, when new material with grains of the same size and original composition is put upon old material to take the place of clogged material removed by scraping the effect is similar to placing coarse sand above fine, and the result is a clogging at the junction. This was found to be the case in Filters Nos. 1 and 6, which indicated furthermore that the finer the material and the nearer the junction was to the surface the quicker the clogging became manifested. To remedy this the filters were spaded over, the old and new material mixed together, so as to break up the layer at the dividing line between the materials of unlike capillary attraction, and satisfactory results followed.

The Management of Sewage Filters with Regard to Winter Weather.

The purification of sewage by intermittent filtration is ordinarily attended with more difficulties during the freezing winter weather than during the remainder of the year, owing to an apparent diminution in the activity of the micro-organisms in the presence of frost; to the less favorable conditions for ventilation because freezing interferes with draining, and the pores of the sand are more or less filled with frost; and to the danger of the sewage freezing to the sand before it disappears, whereby further filtration is impossible until a thaw comes. It is therefore of the utmost importance that the treatment of the filters be such that the conditions for operation be as favorable as possible during the winter.

Most of the experimental filters received their preparation for the winter on December 2, and on the following day severe winter weather began. The filters showed great improvement in the readiness with which they took the applied sewage, but the improvement in the quality of the effluent was far less than would have been the case in warmer weather. This indicates that the filters should be prepared for the winter sufficiently early to be in their best condition in every way when freezing weather begins. It does not appear to be advisable to postpone this treatment in Massachusetts after the 1st of November.

In regard to the preparation necessary, it may be stated that the

clogging should be removed as far as practicable, and in a majority of cases the surface can with great advantage be arranged in alternate ridges and trenches. The ordinary winter sewage is sufficiently warm to melt some of the snow in the trenches, but in so doing becomes so chilled that in many cases a sheet of ice is formed beneath the unmelted snow and above the sand in the trench. The sewage will slowly pass into the sand and form in this way a very inexpensive and effective winter cover. It is also to be mentioned that at Framingham the filters, which were planted with corn (maize), were afforded such covers by allowing the snow and ice to rest upon the corn hills.

Owing to the limited area of the experimental filters there is but little opportunity for lateral filtration (a very important feature in large filters), and it is not practicable to ridge and trench the surface of most of the Lawrence filters because the sewage would pass through in places too quickly. It appears that large filters in actual practice are much less difficult to operate in winter weather than the experimental filters.

Summary and Conclusions.

The several methods of managing filters, with particular reference to the removal of clogging in the surface layers, which have been applied, with varying results, may be summarized as follows: —

1. Systematic raking, with occasional harrowing or ploughing, is very satisfactory, particularly for coarse materials.

2. Systematic scraping at regular intervals (followed by raking to loosen the material) gives very good results, especially for fine materials.

3. Systematic scraping when necessary, without raking or harrowing, is not advisable.

4. The efficiency of very fine material (clogged or not clogged) is much increased by trenching with coarse material.

5. Such trenches should contain carefully graded materials at the bottom to prevent clogging at the junction of the coarse and fine sand.

6. When new material is put on to old to replace clogged material removed by scraping, it is always advisable to mix the old and the new together in order to prevent clogging at the junction of layers of unlike capillary attraction.

7. The removal of stored organic matter by resting for a limited

period is sufficiently great to render this simple and inexpensive method worthy of careful consideration in cases of clogging where the available area is not too limited. It may be mentioned here that the depth of material necessary to be removed from the surface of several of the experimental filters would doubtless have been considerably less if they had been allowed to rest for a short time.

8. It is important that the treatment of filters be such that the conditions of operation be as favorable as possible during the cold winter weather.

9. Great care should be taken, especially in the case of filters of fine material, that the capacity of the filter be not taxed during the winter months to such an extent that more organic matter is stored throughout the sand than can be removed during the spring and early summer, which is the period of highest nitrification.

Experiments upon the Rapid Filtration of Sewage from which the Sludge has been removed by Different Methods.

The question of clogging has been considered in the preceding pages with regard to the removal of sludge after its application to and partial storage in the sand. Another aid to prevention and relief is the removal of as much of the sludge as possible before the application of the sewage to the filter. This may be done by different treatments as follows: —

I. By rapid filtration through coarse gravel, with the aid of a current of air drawn through the gravel.

II. By chemical precipitation.

III. By sedimentation.

IV. By mechanical devices, such as very fine screens or wire cloth. (Results as yet incomplete.)

After treating sewage by one of the first three of these different methods it has been in each case applied to a filter of sand 5 feet deep, having an effective size of grain of 0.17 to 0.19 millimeter.

I. (Filters Nos. 12 A, 15 B and 16 B.)

Filters Nos. 15 B and 16 B are each 65 inches in depth and contain gravel stones of an effective size of 5.10 millimeters. They were put in operation July 25, 1892. A current of air has been drawn through No. 15 B, by means of an aspirator attached to the tank near the bottom, since March 18, 1893, and through No. 16 B since Jan. 16, 1893. The outlet from each filter has been trapped.

The surfaces were not disturbed until the middle of July, 1893, about a year after they were first put in operation. They were each raked 3 inches deep four different times, to remove clogging, between the middle of July and September 1. After September 1, they were raked regularly once a week until October 26, since which date they have been raked 3 inches deep daily. During November and December there was evidence of sub-surface clogging and each filter was spaded over 6 to 8 inches deep on several occasions. No material has been removed from either filter.

Filter No. 12 A contains 60 inches in depth of sand of an effective size of 0.19 millimeter, and receives the effluent of Nos. 15 B and 16 B. Since March 24 it has been scraped when clogged, but not raked. The clogged sand has been washed and replaced. The filter has been scraped on an average once in five days, and the average depth of clogged sand removed was 0.24 inch. Sub-surface clogging made it necessary to spade over the upper six inches of sand after scraping on September 27 and December 12 and 27. The results are summarized beyond.

II. (Filter No. 19.)

This filter is also 60 inches deep, and the sand has an effective size of 0.17 millimeter. It has received the supernatant liquid from sewage after treatment with alum (1,000 pounds per million gallons and allowed to settle four hours). Since October 23 it has been scraped after the same manner as No. 12 A. The average period between scrapings was ten days and the average depth removed was 0.47 inch. Up to December 20 the filter had twice been spaded over 6 inches deep to remove sub-surface clogging. The rate of filtration, 640,000 gallons per acre daily for six days in a week, overtaxed the capacity of the filter, which was allowed to rest for two weeks beginning December 23. The results are summarized beyond.

III. (Filter No. 13 A.)

This filter was constructed on Sept. 27, 1893, and contains 60 inches in depth of sand of an effective size of 0.19 millimeter. It received the supernatant liquid from sewage which had been allowed to settle four hours. It has been scraped on an average once in six days, and the average depth removed was 0.37 inch. In December the sand was spaded over to a depth of 6 inches, three times, to remove sub-surface clogging. The rate of filtration, 480,000 gallons

per acre daily for six days in a week, overtaxed the filter, which was allowed to rest for two weeks beginning December 23. The results are summarized below.

Quantitative Efficiency — Average Rates of Filtration.

(Gallons per acre daily for six days in a week.)

Number of Filter.	Jan. 1 to Dec. 31, 1893.	Oct. 1 to Dec. 31, 1893.
12 A,	819,900	960,000
13 A,	-	416,800
15 B,	404,700	480,000
16 B,	415,200	480,000
19,	267,200	554,000

Qualitative Efficiency — Average Percentage of Removal of Organic Matter and Bacteria.*

	Jan. 1 to Dec. 31, 1893.		Oct. 1 to Dec. 31, 1893.	
	Albuminoid Ammonia.	Bacteria.	Albuminoid Ammonia.	Bacteria.
From sewage by Filter No. 15 B,	77.3	77.4	79.9	84.0
From sewage by Filter No. 16 B,	75.2	80.3	70.5	79.3
From effluent of Filters Nos. 15 B and 16 B by Filter No. 12 A.	81.2	98.9	86.8	99.9
From sewage by Filters Nos. 15 B or 16 B and No. 12 A.	95.5	99.8	96.7	99.9
From sewage by chemical precipitation,	52.4	84.3	55.2	81.6
From clarified sewage (after chemical precipitation), by Filter No. 19.	89.0	95.8	78.7	97.9
From sewage by chemical precipitation and Filter No. 19.	94.6	99.2	90.1	99.6
From sewage by sedimentation,	-	-	18.2	12.0
From clarified sewage (after sedimentation) by Filter No. 13 A.	-	-	89.4	98.6
From sewage by sedimentation and Filter No. 13 A,	-	-	91.3	98.8

* Several of the percentages in this table differ a little from those presented on page 101 of Senate Document No. 4 for 1894, owing to a slight revision of, and an extension of the period covered by, the results.

Summary and Conclusions.

1. Of the three methods given above for the removal of sludge, filtration through coarse gravel at a very rapid rate, and with the aid of a current of air drawn through the gravel, gave the greatest purification. Furthermore, it has the advantage that it burns up the sludge to a large extent and does not call for additional means for sludge disposal.

2. The removal of sludge by sedimentation enables filters of fine material to be operated at higher rates than filters which receive ordinary sewage. It appears that it would be advisable to employ sedimentation in many large filters where the sewage is strong and the filters are not cultivated.

3. The aid received from the removal of sludge by chemical precipitation does not appear to be sufficient to justify the additional cost.

4. Of the three filters of fine sand which receive sewage from which the sludge has been partly removed by different methods, No. 12 A received the best purified sewage and gave the highest efficiency both from a qualitative and a quantitative point of view. This filter also is the only one capable of continuing to work at the rates given above.

5. Upon studying the several methods of obtaining a well purified effluent from sewage we find that the average rate of filtration for the combined area of Filters Nos. 12 A, 15 B and 16 B was 320,000 gallons per acre daily for six days in a week. This is the best result yet obtained with the experimental filters, and this system of double filtration with the aid of a current of air appears to be capable of application to the purification of sewage on a large scale.

Sub-surface Application of Sewage.

Filter No. 7.—This filter contains 44 inches in depth of mixed coarse and fine sand of an effective size of 0.35 millimeter, above which are 10 inches of loam and 6 inches of soil. The sub-surface drain pipe is 6 inches in diameter, with open joints every 2 feet, and is 18 inches below the surface. This pipe became clogged and on April 20 was taken up and cleaned. The sludge removed contained 75 per cent. of the insoluble albuminoid ammonia applied since the pipe was cleaned and relaid in October, 1892. The pipes were again relaid July 8 and sewage applied at the rate of 40,000 gallons per acre daily for six days in a week. The drain pipe is gradually becoming clogged, and since December 1 the full dose could not be applied.

The nitrification was incomplete in August, and the ventilation has been increased by aspiration since September 1. The quality of the effluent has improved and remains very satisfactory.

From the experiments upon Filter No. 7 and observations upon

the sub-surface filters at Lenox and Wellesley we may draw the following conclusions: —

1. From a chemical and biological point of view no marked difficulties attend the purification of sewage applied beneath the surface.

2. As much of the sludge as possible should be removed from the original sewage by screens and sedimentation before applying it to the sub-surface.

3. The sub-surface pipes should be provided with outlet gates at the lower end, opposite the point of application, so that they may be flushed out from time to time to remove the accumulated sludge.

4. In most cases, to avoid clogging, the drain pipe should be surrounded with stones or coarse gravel, and in order to prevent the sand from filling the spaces the gravel should be surrounded with successive layers of material of intermediate and gradually decreasing size.

Experiments with Sand clogged by Sewage.

Filter No. 11A.—This filter was filled in April, 1892, with 5 feet of material which had been scraped from the surface of Filter No. 6 because it was clogged. Aided by a current of air it began to do good work in a few months and in 1893 it filtered sewage at the rate of 60,000 gallons per acre daily for six days in a week with an effluent as well purified as that from some filters of clean material. The purification fell off in the summer, owing to clogging at the surface. In August the upper 3 inches were removed and the quality of the effluent steadily improved and remained satisfactory throughout the year.

This experiment offers a strong confirmation of the conclusion already drawn with regard to the injurious effect of the presence of layers of unlike material in a filter. (Compare Annual Report for 1892, pages 403 and 409, and also the sections in the present Report on the construction of trenches and the addition of new material, pages 417 and 420.) This material, just before its removal, and when it formed a portion of the upper layer 2 inches in depth of Filter No. 6, remained saturated with water and ventilation was precluded because the cleaner sand beneath it was unable to draw the water from it. When placed by itself, however, it drained, allowed air to enter the pores and oxidation processes in time became re-established. In Filter No. 11 A the upper portion eventually contained so much stored organic matter that it remained saturated and the

comparatively clean but actually dirty and partly clogged sand beneath it could not withdraw the water from its pores to allow the entrance of air. There is no reason to believe, moreover, that this portion which was removed would not in time make an efficient filter if placed by itself. This experiment with others shows that the clogging of a sewage filter does not mean the storage in the material of any definite amount of organic matter, but that it arises from differences in capillary attraction of adjoining layers. While it is true of course that increased storage of organic matter means increased capillarity, it is also true that marked differences in capillary attraction occur in unlike material containing very little or no organic matter.

The Effect of Polarite in a Filter on the Removal of Color from Sewage containing Dye Stuff.

Filter No. 14.—This filter has contained since Jan. 21, 1893, a layer of polarite* 7 inches deep, the top of which was 6 inches below the surface. From February 13 to March 22, Patent Blue† equivalent to 0 33 part per 100,000 was put into the sewage, which was applied to the filter at the rate of 160,000 gallons per acre daily for six days in a week. The effluent was slightly colored after a few days, and the color became quite marked at the end of 38 days. The filter was then operated as usual without the dye stuff in the sewage and it was not until August 26 that the effluent became free from the color which had been stored in the filter.

During this time Filter No. 13, of the same construction as No. 14, without polarite, received the same treatment as the latter. The effluent of each was uniformly well purified with high nitrification.

Beginning on August 26, Scarlet 2 R (another aniline dye), equvalent to 0.44 part per 100,000, was added to the dose of each filter. The applied sewage had a strong red color. On the second day the effluent of No. 13 (without polarite) showed a pink tint and

* Analysis of polarite by Professor Roscoe: —

Magnetic oxide of iron,	53 85
Alumina,	5 68
Magnesia,	7.55
Water, with a trace of carbon,	5 41
Silica,	25.50
Lime,	2.01
	100.00

† Trade name for an aniline dye.

contained about 20 per cent. of the color in the applied sewage on the twelfth day of the application. The first appearance of color in the effluent of No. 14 was on the twenty-second day, and the color had not become marked on the twenty-eighth day, when the application of this dye was stopped.

On September 24 Patent Blue was added to the dose of each filter (0.33 part per 100,000 — the same as applied to No. 14 during the winter months), and the effluent of No. 13 was strongly colored on the first day, while that of No. 14 was tinted only very slightly.

The Removal of Bacteria.

The number of bacteria in the effluent of a sewage filter depends upon the size of the material and the condition of the filter. With filters of very fine sand such as Nos. 2 and 4 it is probable that no bacteria pass through from top to bottom. When the nitrification is very incomplete and there has been considerable storage of organic matter in the sand, the number of bacteria in the effluent frequently increases. These bacteria, however, belong to one or more hardy species which are able to multiply within the filter. Thus, in the case of Filter No. 2 in March, 1893, the bacteria in the effluent were comparatively high and were nearly a pure culture of a liquefying, fluorescent bacillus.

Filters Nos. 6 and 9 A, when operated under the most favorable conditions, appear to allow no bacteria to pass through from top to bottom. When operated at high rates of filtration, however, a very small percentage of the applied bacteria, as a rule, passes through the filters.

With materials as coarse as those in Filters Nos. 1, 5 A and 15 B there are always some bacteria which pass directly through the filter. The number of bacteria decreases as the distance from the point of application to the underdrains and the time taken to travel this distance increases.

With regard to seasonal effect, it is to be stated that generally speaking the winter months are the time of least efficiency, because the conditions for nitrification and other processes are then least favorable. When a filter is in good condition it is possible to obtain normal bacterial results in the winter, and as most increases in the number of bacteria in the effluent come from disarrangements of the functions of the filters, periods of unusually low bacterial removal may be found at all times of the year.

WORK OF THE FILTERS FOR 1893.

The experimental filters used during 1893 for sewage purification have been mainly the ones which have been fully described in previous Reports of the Board. In the following table are given the descriptions of the materials used. This is followed by an outline of the history of each filter and the monthly averages of the analyses.

Construction of Experimental Sewage Filters studied in 1893.

Number of Filter.	Dimensions of Filters. Depth of Sand. Inches.	Mean Diameter. Inches.	Area in Fractions of an Acre.	Size of Sand. Effective Size in Millimeters, 10 per Cent. Finer than—	Uniformity Coefficient.	Manner of Filling.	In Operation since—	Remarks.
1, . .	63	200	1/200	.48	2.4	Wet.	Jan. 10, 1888.	- -
2, . .	60	200	1/200	.08	2.0	Wet.	Dec. 19, 1887.	Contains two trenches of coarse sand.
3 A, .	60	200	1/200	.48 .08	2.4 2.0	Dry. Dry. Wet.	Jan. 6, 1890.	Discontinued Sept. 1, 1893.
4, . .	60	200	1/200	.04	2.7	Wet.	Dec. 19, 1887.	Contains two trenches of coarse sand.
5 A, .	63	200	1/200	1.40	2.4	Dry.	Sept. 14, 1891.	- -
6, . .	44	200	1/200	.35	7.8	Wet.	Jan. 12, 1888.	- -
7, . .	44	200	1/200	.35	7.8	Wet.	Jan. 14, 1888.	Covered with 16 inches of loam and soil; sewage applied beneath the surface.
9 A, .	60	200	1/200	.17	2.0	Dry.	Nov. 18, 1890.	- -
11 A, .	60	20	1/20,000	.35	7.8	Dry.	Mar. 30, 1892.	Filled with clogged material from No. 6.
12 A, .	60	20	1/20,000	.19	2.0	Dry.	July 25, 1892.	- -
13, . .	63	20	1/20,000	.48	2.4	Wet.	Feb. 16, 1888.	Discontinued Sept. 27, 1893.
13 A, .	60	20	1/20,000	.19	2.0	Dry.	Sept. 27, 1893.	- -
14, . .	63	20	1/20,000	.48	2.4	Wet.	Feb. 16, 1888.	Contains layer of polarite.
15 B, .	65	20	1/20,000	5.10	2.0	Dry.	July 25, 1892.	Constantly aerated.
16 B, .	65	20	1/20,000	5.10	2.0	Dry.	July 25, 1892.	Constantly aerated.
17 A, .	60	20	1/20,000	.17	2.0	Wet.	Jan. 28, 1890.	Contains layers of marble dust.
19, . .	60	20	1/20,000	.17	2.0	Wet.	Jan. 28, 1890.	- -
25, . .	120	20	1/20,000	-	-	Wet.	Jan. 1, 1890.	Filled with loam and soil. Contains carcass of dog.
30, . .	30	17	1/27,900	.48	2.4	Dry.	May 31, 1890.	- -
31, . .	30	17	1/27,900	.17	2.0	Dry.	May 31, 1890.	- -
32, . .	30	17	1/27,900	.17	2.0	Dry.	Dec. 5, 1891.	- -

Filter No. 1.

At the beginning of the year the surface of this filter, unprotected from the weather, was considerably clogged by organic matters stored in the sand, and during the extreme cold weather of January the nitrification was very slight, while the ammonias in the effluent became exceptionally high. The applied sewage, equivalent to 120,000 gallons per acre daily for six days in a week, at times disappeared very slowly and in a few instances froze to the sand. In this case the ice was removed with a pick and shovel in order to keep the filter in action. In February the quality of the effluent improved somewhat, but was still poor, owing to imperfect ventilation and probably to the passage of the sewage through portions of the filter where there was the least frost. From March 8 until the middle of April, ventilation was increased by drawing air through the sand by means of an aspirator attached to the outlet pipe, the end of which was trapped. The quality of the effluent improved until about the first of May, when the spring rains caused the surface to be partially covered for several days, but then began to deteriorate, and on May 5, 4 inches of discolored and partially clogged sand were removed and 9 inches of fresh material were added to bring the filter up to its original depth of 63 inches. Nitrification soon became high and remained so during the summer in the absence as well as in the presence of aspiration. The ammonias in the effluent became low and it is to be stated that in July and August the albuminoid ammonia was caused in part by the presence of small white worms which appeared to live in the underdrains. During the warm weather there was a removal, by nitrification, of considerable organic matter which had been stored in the sand. In October the ammonias began to increase in the effluent, owing to the interruption in the ventilation caused by clogging, at the junction of layers of old and new sand. On December 2, the surface was spaded over, 12 inches deep, in two layers of 6 inches each. The quality of the effluent improved up to the middle of the month, when the very cold weather interfered with the purification, but not with the quantitative efficiency. The poorest result of the month was on December 19, when the albuminoid ammonia in the effluent was .2260 part. The cause of this doubtless was that the sewage passed through holes in the frost made at the points where the warm sewage first reached the sand.

Effluent from Filter No. 1.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as —		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	120,000	45	34½	3h.	7½	Slight	.71	2.5000	.2910	7.33	.0725	.0000	1.86	329,000
February, .	120,000	45	35½	1h.	5½	Slight	.47	1.6900	.2035	5.83	.2675	.0365	1.38	298,750
March, .	120,000	43½	37½	1h. 30m.	3	Slight	.40	.6200	.1042	5.77	1.2200	.0394	.72	63,937
April, .	120,000	46	43½	1h. 30m.	0	V. sl.	.29	.1225	.0675	6.29	1.4575	.0036	.45	37,625
May, . .	102,000	55	55	2h. 30m.	0	V. sl.	.32	.1406	.0721	5.69	2.5137	.0188	.48	57,625
June, . .	120,000	69	67½	1m.	0	V. sl.	.29	.0363	.0548	9.58	3.2333	.0191	.41	48,625
July, . .	75,000	73	74	1m.	0	None.	.27	.0093	.0488	8.11	4.0050	.0082	.32	33,000
August, .	54,400	68	74	1m.	0	None	.19	.0090	.0501	7.93	3.5625	.0044	.26	20,500
September,	96,200	63	69	2m.	0	None.	.17	.0085	.0296	7.92	3.0730	.0059	.26	23,280
October, .	120,000	56	60	9m.	0	V. sl.	.21	.0270	.0363	7.94	2.5800	.0015	.30	49,500
November,	120,000	46	50	15m.	3	V. sl.	.39	.4132	.0796	7.47	2.1175	.0075	.52	139,500
December,	103,800	47	40	1h. 25m.	6	Dec.	.51	1.2417	.1307	6.64	1.4200	.1307	.84	92,000

Sewage applied, 600 gallons, 6 times a week, from January 1 to July 8; 150 gallons, 12 times a week, from July 10 to August 31; 200 gallons, 12 times a week, September 1 to 16; 300 gallons, 12 times a week, September 18 to December 1; 600 gallons, 6 times a week, December 2 to 23; 300 gallons, 6 times a week, to December 31. Experiments interrupted by high water, May 5 to 8. May 5, 4 inches dirty sand removed from surface. May 11, 9 inches of new sand put on surface. December 2, 6 inches of sand taken off; next 6 inches turned over, upper 6 inches replaced and mixed with sand below. Air drawn through sand 15 minutes daily, from March 6 to 17; 12 hours daily, March 18 to April 15; 6 hours daily, May 11 to July 10; 3 hours daily, July 31 to September 1. Surface raked about 1 inch deep each week. During the winter months snow was removed 17 times (total depth, 62 inches); ice removed 11 times (total depth, 7.5 inches).

Filter No. 2.

This filter of fine sand was badly clogged at the surface at the beginning of 1893, and although protected by a canvas cover and continuing to give an effluent of excellent quality it could filter but a very small amount of sewage. During January and February the sewage repeatedly froze to the sand and the ice was removed with a pick. The ammonias in the effluent were very low, but nitrification gradually decreased and there was a considerable storage of organic matter in the sand. On March 4 two circular trenches two feet deep and one foot wide, one and a half and five feet, respectively, from the edge of the filter, were constructed. These trenches were filled with No. 9 sand, as is described on page 417, and covered with boards until April 1. The applied sewage equivalent to 40,000 gal-

lons per acre daily for six days in a week disappeared promptly. The ammonias and the nitrates steadily increased until May, after which the ammonias steadily decreased and the nitrates remained high during the entire summer, indicating a removal of much organic matter from the sand. The grass and weeds which grew luxuriantly around the edges of the trenches were cut on July 20 and August 31. The dose was increased September 1 to 60,000 gallons per acre, and the filter continued to do excellent work until the latter part of October, when the trenches began to clog and the increasing free ammonia in the effluent indicated that the ventilation was imperfect. The upper two inches of discolored and partially clogged material were removed from each trench on October 30 and replaced with new sand. This did not restore the efficiency of the filter, owing to a clogging at the bottom of the trenches, which was remedied on December 2 by putting in several layers of mixed coarse and fine sand, as is described on page 417. On December 4 the trenches were covered with boards. This treatment restored the quantitative efficiency of the filter, and the quality of the effluent steadily improved.

Effluent from Filter No. 2.

[Parts per 100,000.]

Sewage applied twice in January, four times in February; 400 gallons 3 times a week, March 1 to 15; 200 gallons 6 times a week, March 15 to August 31; 300 gallons 6 times a week, September 1 to December 31. Surface protected by canvas cover until March 4. Trenches protected by boards from March 4 to April 1, and from December 4 to 31. Experiments interrupted by high water May 5 to 8. Two trenches dug 2 feet deep and filled to within 3 inches from top with No. 9 sand March 4. October 30, 2 inches of dirty sand removed from trenches and replaced by clean material. December 2, coarse sand and 2½ inches of fine sand removed from trenches and replaced by mixed coarse and fine for 6 inches, and then filled with coarse. Surface of trenches raked 1 inch deep each week. Grass and weeds cut July 20 and August 31. Ice removed January 11, 18, 31 and February 24.

Filter No. 3 A.

In January the prescribed dose, equivalent to 60,000 gallons per acre daily for six days in a week, was taken with some difficulty, owing to the accumulation of organic matter at and near the surface. The quality of the effluent was poor and became worse, although the quantitative efficiency was satisfactory in February. In March the ammonias in the effluent began to steadily decrease, but the free ammonia was still very high. Nitrification slowly improved and became very high in June and July, when there was considerable removal of organic matter stored in the sand. The effluent was well purified. Early in August the surface sand became clogged so that the sewage remained on the surface for twenty-four hours. On August 14 the surface was spaded over, corresponding to ploughing, to a depth of six inches, after which the applied sewage disappeared promptly. Ventilation was restored and the quality of the effluent, which had begun to deteriorate, became good again, with the nitrates very high at the end of the month, when the experiment was discontinued.

Effluent from Filter No. 3 A.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	39,200	45	37½	17h.	8	None.	.17	1.0100	.0990	9.02	.6825	.0216	.55	2,035
February, .	60,000	44	36	45m.	7	None.	.21	2.4600	.1580	6.57	.1450	.0227	.83	1,555
March, .	60,000	44	37	1h.	4	V. sl.	.37	2.2875	.0675	5.43	.2975	.0029	.56	975
April, .	60,000	45	43	6m.	0	None.	.24	1.2525	.0600	5.48	1.1625	.0033	.42	72
May, . .	55,400	56	51½	1h. 15m.	0	None.	.17	.4244	.0422	6.18	1.7322	.0038	.28	83
June, . .	60,400	70	64½	54m.	0	None.	.13	.0683	.0374	8.16	3.7411	.0031	.23	12
July, . .	60,000	74	71	51m.	0	None.	.06	.0386	.0308	11.05	3.8100	.0005	.15	27
August, .	55,400	70½	72½	12m.	0	None.	.05	.0338	.0203	7.81	2.9400	.0006	.14	23

Sewage applied, 300 gallons 6 times a week. Experiments interrupted by high water May 5 to 8, and May 18 and 19. Surface raked about 1 inch deep each week. Air drawn through sand 15 minutes daily March 13 to 17; 12 hours daily March 18 to April 15. August 14, surface spaded 6 inches deep. Snow and ice removed January 5, 6, 7, 10, 12, 14, 16, 17, 20, 24, 25, 30, 31; February 2, 3, 4, 6, 13, 14, 18, 21, 22, 24, 27, and March 1 and 4.

FILTER No. 4.

This filter of fine river silt with a large trench of coarse sand and covered with canvas was able to filter sewage at the average rate of 40,000 gallons per acre daily for six days in a week until the early part of March. The ammonias in the effluent were very low, but the nitrates decreased steadily and there was a large storage of organic matter in the sand. To remove the clogging the upper 2 inches of coarse sand in the trench were removed on March 6. This did not remedy matters and on March 11 the canvas cover was removed, the coarse sand dug out of the trench and about ½ inch in depth of clogged fine sand at the junction of the coarse sand of the trench with the fine sand of the filter scraped off; and the coarse sand was replaced after raking the fine sand to a depth of about 1 inch. This treatment did away with clogging until the last of May. During this time the nitrates and ammonias in the effluent increased. The trench failed to take the sewage promptly toward the last of May and on June 2 a new trench was constructed. The average rate was reduced June 2 to 30,000 gallons per acre daily and the quality of the effluent steadily improved until the last of September, when the purification was excellent. The grass and weeds were cut on August 31. Toward the latter part of October the new trench became clogged and it was allowed to rest and the old one used during the rest of the year. The nitrification decreased in December, although the effluent was very free from organic matter. While the effluent contained but a comparatively small amount of albuminoid ammonia throughout the year, it is to be stated that there was a continual storage of organic matter in the sand.

Effluent from Filter No. 4.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January,	40,400	44	40	24h.	1½	None.	.18	.0006	.0120	7.23	1.1725	.0000	.23	2
February,	36,600	44	38½	24h.	¾	None.	.17	.0007	.0163	3.75	.7100	.0001	.24	9
March,	32,600	42	37½	24h.	0	None.	.21	.0401	.0458	4.70	.2840	.0001	.44	230
April,	41,600	43½	41	21h.	0	None.	.32	.2750	.0495	4.52	.6350	.0015	.50	27
May,	33,000	57	50½	12h.	0	None.	.34	.2289	.0449	4.52	.8457	.0068	.48	22
June,	28,000	69	62½	1h. 30m.	0	None.	.31	.1882	.0436	7.24	.8144	.0060	.45	27
July,	30,000	74½	66½	27m.	0	None.	.26	.1475	.0480	7.90	1.4050	.0155	.46	90
August,	28,800	69½	70	25m.	0	None.	.29	.1625	.0395	9.01	2.0225	.0074	.45	19
September,	30,000	63	65½	47m.	0	None.	.22	.0210	.0290	9.23	2.1660	.0032	.31	20
October,	29,400	56	62	1h. 20m.	0	None.	.14	.0020	.0149	8.20	3.1025	.0002	.21	13
November,	29,200	45	52½	6h.	0	None.	.14	.0014	.0134	7.27	2.7080	.0001	.20	11
December,	28,600	45	44	18h.	1	None.	.13	.0019	.0191	5.79	1.5775	.0002	.21	42

Sewage applied, 400 gallons, 3 times a week until May 12; 200 gallons, 6 times a week, May 13 to June 1; 300 gallons, 3 times a week, June 2 to December 22; 150 gallons, 6 times a week, December 22 to 31. Surface protected by canvas cover till March 11; tank covered with boards, December 4. Experiments interrupted by high water, May 5 to 8 and May 18 and 19. Surface of trench raked about 1 inch deep each week. May 6, 3 to 4 inches of turf removed from surface outside of trench. July 31, entire surface raked over. March 6, 2 inches of dirty sand removed from trench. March 11, coarse sand taken out and replaced after scraping ½ inch from fine sand. June 2, a new trench dug 1 foot inside of old trench, 1 foot wide and 2 feet deep, and filled with coarse sand. New trench used June 2 to October 30. August 31, grass and weeds on surface cut.

Filter No. 5 A.

This filter of fine gravel stones without sand received sewage in January and February in single doses equivalent to 120,000 gallons per acre daily for six days in a week. The surface was unprotected from the weather and with a few exceptions the sewage disappeared promptly. The nitrification was incomplete and the ammonias in the effluent were very high. This was probably owing to a certain extent to the passage of the sewage through the portion of the filter near the point of application and where there was the least frost. In March the quality of the effluent improved, owing in part to the fact that the sewage was applied in three doses daily, and partly to increased ventilation by aspiration. In April, without aspiration, the effluent continued to improve in quality, and in May there was a removal of organic matter from the sand. The filter became clogged

in the early part of June, at a point just below that reached in the weekly raking, to a depth of 1 inch. This was remedied by raking to a depth of 2 inches. The purification was very good for this material in July and a part of August; but sub-surface clogging appeared again in September, and the surface was spaded over, 6 inches deep, corresponding to ploughing, on September 15. On October 30 the rate was increased to 160,000 gallons per acre daily, applied in eight doses daily for six days in a week, and there was no marked deterioration in the quality of the effluent until the last of November, when the filter became clogged again beneath the surface. Two inches of discolored and partially clogged gravel were removed on December 2, and the surface spaded over, 6 inches deep. In December the applied sewage, equivalent to 120,000 gallons per acre, was taken readily, but the nitrification was incomplete and the ammonias in the effluent were very high during the maximum flow.

Effluent from Filter No. 5 A.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.			Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	115,400	43	36	1h.	9	Dec.	.67	1.7050	.2285	6.01	.5675	.0073	1.45	337,500
February,	110,000	42	36	1h. 27m.	7	Dec.	.46	1.3325	.2570	8.31	.8050	.0190	1.47	458,750
March, .	120,000	40	37½	1h.	5	V. sl.	.28	.6325	.1330	5.29	1.5450	.0163	.78	419,375
April, .	120,000	45	45	50m.	0	V. sl.	.30	.3450	.1127	6.07	1.8112	.0115	.61	150,000
May, .	102,200	54	54½	-	0	V. sl.	.18	.0371	.0549	5.92	2.7600	.0026	.26	46,750
June, .	120,000	67	67	-	0	V. sl.	.57	.3071	.0762	9.82	1.5033	.0030	.47	60,500
July, .	106,200	72	73	-	0	V. sl.	.24	.0115	.0550	9.20	1.9950	.0063	.26	43,750
August, .	112,600	69½	73	18m.	0	V. sl.	.22	.0445	.1040	10.69	2.3500	.0057	.45	42,000
September,	120,000	66	68	27m.	0	Dec.	.52	.3376	.0691	7.90	2.0000	.0244	.58	107,600
October, .	123,000	56	60½	21m.	0	Dec.	.29	.1234	.0648	7.68	2.5400	.0045	.35	358,750
November,	160,000	45	49	40m.	0	Dec.	.26	.3325	.0770	7.55	2.5425	.0070	.39	122,250
December,	120,800	42	40	25m.	7	Dec.	.76	1.7533	.2867	6.35	1.4240	.0520	1.57	341,500

Sewage applied, 600 gallons, 6 times a week until March 6; 200 gallons, 18 times a week, March 7 to October 28; 100 gallons, 48 times a week, October 30 to December 2; 600 gallons, 6 times a week, December 2 to 11; 300 gallons, 12 times a week, December 12 to 14; 600 gallons, 6 times a week, December 15 to 22; 300 gallons, 12 times a week, December 23 to 31. Experiments interrupted by high water, May 5 to 8 and May 18 and 19. Surface raked 1 inch deep each week. June 12, surface raked 2 inches deep. Surface spaded 6 inches deep September 15 and December 2. Two inches dirty gravel removed from surface December 2 Air drawn through sand fifteen minutes daily, March 6 to 18; two hours, three times daily, May 8 to September 1. Snow removed during the winter months 23 times (70 inches total depth); ice removed 9 times (2.9 inches total depth).

Filter No. 6.

This filter, 44 inches in depth of mixed coarse and fine sand and unprotected from the weather, received sewage at the beginning of 1893 at the rate of 70,000 gallons per acre daily for six days in a week. Owing to a storage of organic matter in the surface sand the sewage on very cold days froze to the sand, and it was necessary to omit some doses in January and to remove the ice in places with a pick and shovel in order that the filter might be kept in action. Nitrification was very incomplete in January and the ammonias in the effluent were high. The quantitative efficiency was satisfactory in February, but the effluent deteriorated in quality, owing, in part, to the fact that the oxidation and nitrification functions were thrown out of adjustment by the unfavorable conditions of the preceding weeks, but chiefly to the passage of the sewage through holes in the frost. In March and April the filter steadily improved, while from May to August, inclusive, the effluent was very well purified and moreover there was a removal of a large amount of organic matter which had been stored in the sand. On July 11 the quantity of sewage applied to the filter was increased to 90,000 gallons per acre daily. Surface clogging appeared early in September, and on September 25 the upper 2 inches of discolored and partially clogged sand were removed and replaced with fresh material. The filter did good work again until the last of November, when a clogging occurred at the junction of the old and new sand, as is described on pages 413 and 414. This was remedied on December 2 by spading the surface to a depth of 6 inches. A canvas cover was put on December 4. The purification was quite incomplete during the first half of December, but there was a gradual improvement during the last half of the month.

Effluent from Filter No. 6.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. — Sewage.	Temperature. Deg. F. — Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance. — Turbidity.	Appearance. — Color.	Ammonia. — Free.	Ammonia. — Albuminoid.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	38,000	45	38½	24m.	9	V. sl.	.29	1.1350	.0825	8.40	.3325	.0230	.74	17,275
February, .	67,000	44	34½	1h. 13m.	7	V. sl.	.39	1.7750	.1775	5.86	.1775	.0241	.89	50,925
March, .	70,000	42	38	50m.	6	V. sl.	.24	1.6925	.1040	4.92	1.2962	.0461	.53	13,129
April, .	70,000	44	44½	6m.	0	V. sl.	.19	.3562	.0567	5.22	2.8187	.1533	.45	5,145
May, . .	59,600	54	53	3m.	0	None.	.14	.0117	.0384	6.12	3.6060	.0005	.24	4,948
June, .	70,000	67	65½	10m.	0	None.	.13	.0066	.0350	10.26	3.9700	.0002	.21	2,775
July, . .	75,800	72	72½	5m.	0	None.	.08	.0043	.0357	9.99	2.8833	.0181	.19	10,500
August, .	83,600	70½	73	14m.	0	V. sl.	.11	.0246	.0316	9.52	2.3125	.0406	.20	10,640
September,	86,600	64	68	4h. 30m.	0	None.	.15	.0955	.0362	7.33	1.4100	.0844	.27	3,732
October, .	90,000	57	61	36m.	0	None.	.10	.0555	.0284	8.10	3.6825	.0113	.18	3,765
November,	86,600	44½	47	1h.	0	V. sl.	.14	.0477	.0284	6.10	2.5140	.0741	.27	5,802
December,	77,600	43	40	12m.	1	V. sl	.27	.5800	.0820	6.79	1.2720	.7200	.89	12,840

Sewage applied, 350 gallons, 6 times a week, until July 10; 450 gallons, 6 times a week, July 11 to December 21; 250 gallons, 6 times a week, December 22 to 31. Experiments interrupted by high water May 5 to 8 and May 18 to 20. Surface raked about 1 inch deep each week. September 25, about 2 inches of dirty sand scraped off and replaced by new material. December 2, surface spaded 6 inches deep. Canvas cover put on December 4. Snow removed during the winter months 17 times (63 inches total depth); ice removed 10 times (14.5 inches total depth).

Filter No. 7.

Sub-surface Application of Sewage.

This filter contains 44 inches of mixed coarse and fine sand like that in No. 6, above which are 10 inches of loam and 6 inches of soil. The sewage is applied in a circular pipe 6 inches in diameter and 18 inches below the surface, with open joints every 2 feet. At the beginning of the year the inlet to this pipe was trapped. After cleaning and relaying this pipe in October, 1892, the sewage was applied without difficulty during the winter months at the rate of 40,000 gallons per acre daily for six days in a week. The nitrification was very incomplete and the effluent contained very high free ammonia. It was thought that the ventilation was interfered with by the rain and melted snow which accumulated upon and at times froze to the surface. On March 15 the quantity of sewage was reduced to 20,000 gallons, but nitrification disappeared entirely

and a reducing action set in, showing that the filter was overdosed. The application of sewage was stopped on April 17 and the sub-surface pipe dug up April 26. In places the accumulated sludge more than half filled the pipe. Analyses showed that this sludge was equivalent to 75 per cent. of the insoluble albuminoid ammonia applied since the pipe was last cleaned. The pipe was relaid without the trap on July 8 and sewage applied at the rate of 40,000 gallons per acre daily for six days in a week. The pipe gradually clogged and the full dose could not be applied after December 1. The nitrification was very high in July, indicating a removal of stored organic matter, but became incomplete in August. Ventilation was increased by aspiration after September 1 and the quality of the effluent improved and remained very satisfactory throughout the year.

For a summary of the information obtained from the experiments upon the sub-surface application of sewage see page 425.

Effluent from Filter No. 7.

[Parts per 100,000.]

Sewage applied, 200 gallons, 6 times a week till March 10; 100 gallons, 6 times a week, March 11 to April 15. None applied April 17 to July 8; 200 gallons, 6 times a week, July 10 to Nov. 20, after which the quantity which could be applied decreased to less than 200 gallons a week. April 26, drain pipe removed and cleaned, replaced without trap at inlet, July 8. Air drawn through filter twelve hours each day, September 1 to October 20. Air drawn constantly through the filter from October 28 to November 17, and from December 2 to December 25.

Filter No. 9 A.

This filter was protected from the weather by a canvas cover and took sewage without difficulty at the rate of 120,000 gallons per acre daily for six days in a week. The surface was not raked, but scraped when necessary, to relieve clogging. The quality of the effluent deteriorated during January, but began to steadily improve in the latter part of February. On March 6 the canvas was removed and the surface scraped. During April, May and June the effluent was very well purified and there was a removal of organic matter stored in the sand. The purification remained satisfactory until November, when sub-surface clogging appeared. The results obtained upon this filter which are presented below are discussed on page 414.

Effluent from Filter No. 9 A.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Average Depth of Frost. — Inches.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	120,000	46½	36½	8h.	3	V. sl.	.36	1.5400	.1215	9.76	.3350	.0044	.65	39,600
February, .	120,000	44	36	6h. 30m.	3	V. sl.	.40	1.4650	.1300	5.98	.4975	.0115	.79	73,750
March, .	120,000	42	38	3h.	½	None.	.10	.4135	.0419	5.74	1.4783	.0083	.29	8,767
April, .	120,000	45	44½	–	0	None.	.09	.0078	.0257	6.07	2.5425	.0001	.22	3,875
May, . .	97,600	53	54	40m.	0	None.	.09	.0060	.0199	5.85	3.2775	.0004	.19	685
June, . .	120,000	66	67	53m.	0	None.	.10	.0228	.0204	9.98	3.5240	.0000	.19	904
July, . .	113,000	71	72	45m.	0	None.	.12	.0263	.0302	8.84	2.9433	.0009	.18	3,750
August, .	106,600	70	72	18h.	0	None.	.06	.0048	.0199	8.45	2.5050	.0001	.16	547
September,	110,800	63	67½	6h. 30m.	0	None.	.19	.1232	.0405	7.71	2.2260	.0078	.27	1,677
October, .	114,400	56	60	10h.	0	None.	.11	.0680	.0256	8.00	2.8575	.0009	.18	2,387
November,	101,000	45	48	16h. 30m.	0	Slight	1.00	2.5775	.1180	8.25	.3500	.0083	1.04	9,175
December,	97,000	45½	38	8h. 15m.	6	Dec.	.50	2.4433	.1240	6.07	.9300	.0190	.60	15,787

Sewage applied, 600 gallons, 6 times a week until December 22, when 300 gallons began to be applied 6 times a week. Surface protected by canvas cover till March 7. Dirty sand scraped from surface March 7, March 14, April 24, July 31, September 1, September 23, October 21, November 6, 16, 18, 20, 21, 22. Filter restored to original depth with clean sand March 14, September 25. The sand removed November 16 to 22 with ½ inch of new sand replaced December 2. Experiments interrupted by high water May 18 to 20. Weeds cut July 13, and pulled up July 31.

Filter No. 11 A.

This filter contains 5 feet of mixed coarse and fine sand which had become clogged and had been removed from the surface of Filter No. 6. Sewage was applied at the rate of 60,000 gallons per acre daily for six days in a week. The effluent was well purified during the winter but began to deteriorate the later part of March, and nitrification decreased steadily. This was caused by incomplete ventilation as the scum at the surface was too thick to dry and crack between doses. Aspiration was tried in July and gave some relief, but to insure permanent improvement the upper 3 inches were removed on August 16, and aspiration tried until September 22. The effluent was very well purified in September and showed a removal of organic matter stored in the sand. The quality of the effluent remained satisfactory through the rest of the year in the absence of aspiration.

For a discussion of this experiment see page 426.

Effluent from Filter No. 11 A.

[Parts per 100,000.]

1898.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	60,000	48	41½	7m.	V. slight.	.29	.0238	.0580	8.13	1.8550	.0031	.39	78,500
February, .	60,000	45½	42½	6m.	V. slight.	.30	.0396	.0570	6.04	1.9950	.0082	.40	116,000
March, .	60,000	43	43½	4m.	V. slight.	.25	.0980	.0650	6.68	1.9950	.0008	.40	17,025
April, .	60,000	45	46	7m.	V. slight	.31	.1500	.0560	5.89	1.2000	.0022	.47	44,000
May, .	46,600	53	52	-	V. slight.	.31	.1647	.0793	5.97	1.2333	.0016	.48	42,000
June, .	60,000	66	61	5m.	Slight.	1.17	.3050	.0910	9.82	.5150	.0035	.64	43,000
July, .	60,000	71	68	9m.	Decided.	1.31	.1500	.0950	8.68	.5450	.0070	.65	56,500
August, .	60,000	70	70	9m.	Slight.	.70	.0960	.0880	9.90	.7200	.0019	1.16	46,000
September, .	60,000	63	61	11m.	Decided.	.40	.0260	.0620	10.76	3.1050	.0021	.46	11,690
October, .	60,000	56	56	8m.	Decided.	.36	.1107	.0573	8.96	2.1800	.0087	.35	41,067
November, .	60,000	45	49½	12m.	Decided.	.35	.0430	.0460	9.64	2.7200	.0030	.33	46,500
December, .	60,000	41	44	16m.	Decided.	.29	.0460	.0560	6.34	1.9700	.0035	.37	53,000

Sewage applied, 3 gallons, 6 times a week. Surface raked 3 inches deep each week. Air drawn through sand from July 10 to 20; eighteen hours a day July 31 to August 31, and continuously September 1 to 22. Experiments interrupted by high water March 16, May 5 to 8 and 18 to 20. August 14, 3 inches removed from surface.

FILTERS NOS. 12 A, 15 B AND 16 B.

Filter No. 12 A contains 60 inches in depth of fine sand, and has received the effluents of Filters No. 15 B and 16 B which are filled with coarse gravel. An aspirator was attached to No. 15 B on March 18, and to No. 16 B on January 16. The rate of filtration has been very high for each of these filters — equivalent to 480,000 gallons per acre daily for six days in a week, for the last seven months. The surfaces of these gravel filters were not disturbed until July, 1893, about a year after they were first put in operation. They were raked 3 inches deep once a week after September 1, and daily after October 26. The quality of the effluent was found by series of analyses to be closely dependent upon the current of air drawn through the gravel. Toward the end of the year it was found that the ventilation was less complete than usual, owing to a leak around the outlet pipe. This doubtless explains, to a great extent, the deterioration in the quality of the effluent and also the clogging of the gravel, which necessitated raking on several occasions to a depth of 6 inches.

The effluents of these gravel filters were uniformly well purified by No. 12 A, when operated at a rate of 960,000 gallons per acre daily for six days in a week. Since March 24 the surface has been scraped when necessary to relieve clogging, and has not been raked. It was scraped on an average once in five days, and the average depth removed was 0.24 inch. The removed sand was washed and replaced. To do away with sub-surface clogging the filter was raked to a depth of 6 inches on September 27, December 12 and 27. The deterioration in the quality of the effluents of Filters No. 15 B and 16 B in December, began to make itself apparent toward the end of the year, in the operation of this filter.

These results are discussed on page 422.

Effluent from Filter No. 12 A.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	480,000	42	45	26m.	None.	.14	.0119	.0234	6.10	1.4850	.0001	.21	6,622
February, .	542,000	48	46	36m.	None.	.12	.0013	.0261	5.47	1.4425	.0000	.21	5,919
March, .	606,000	44	46	33m.	None.	.12	.0130	.0338	6.48	1.6550	.0003	.29	1,125
April, . .	720,000	47	50½	1h. 20m.	V. slight.	.22	.0067	.0470	6.51	1.7525	.0002	.30	9,026
May, . .	658,000	54	54	-	None.	.22	.0033	.0405	5.81	1.8775	.0008	.30	900
June, . .	1,072,000	63	63	37m.	None.	.22	.0037	.0254	9.41	1.6900	.0000	.28	346
July, . .	960,000	70	68	1h. 14m.	None.	.19	.0038	.0292	8.12	1.5650	.0002	.28	121
August, .	960,000	68	68½	1h. 24m.	None.	.15	.0035	.0267	7.72	1.5180	.0000	.25	76
September, .	960,000	60	60½	1h. 12m.	None.	.13	.0044	.0205	9.90	1.3500	.0001	.22	347
October, .	960,000	56	55½	1h. 30m.	None.	.12	.0027	.0211	7.76	1.3750	.0001	.21	129
November, .	960,000	48	50½	1h. 30m.	None.	.17	.0049	.0191	13.92	1.2975	.0002	.24	136
December, .	960,000	44	46	2h. 10m.	None.	.18	.0680	.0255	6.06	1.2820	.0020	.27	394

Effluent of Filters Nos. 15 and 16 applied 6 days a week, as follows: 24 gallons till February 12; 30 gallons, February 13 to March 17; 36 gallons, March 18 to May 13; 48 gallons, May 15 to June 10; 60 gallons, June 12 to 25; 48 gallons, June 26 to December 31. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 18 to 21. Surface raked to a depth of about 3 inches once a week until March 24. Surface scraped and sand of previous scraping (after washing) replaced on following dates: March 24, April 11, May 11, 26, June 13, 15, 19, 20, 21, 24, 29, July 4, 5, 11, 14, 18, 20, 29, August 8, 18, 30, September 5, 9, 12, 16, 19, 20, 23, 25, 27, October 26, November 18, December 2, 7, 27. Spaded 6 inches deep September 27, December 10 and 27.

Effluent from Filter No. 15 B.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	240,000	48	42	-	Decided.	.89	1.0450	.1280	6.60	.0450	.0062	.85	470,000
February, .	240,000	45½	43½	-	Decided.	.47	1.0375	.1350	5.85	.0350	.0004	.93	273,000
March, .	274,000	48	44	37m.	Decided.	.55	.8675	.1500	6.37	.5575	.0005	1.05	177,750
April, . .	360,000	45	48	11m.	Decided.	.46	.4000	.1610	6.21	1.3675	.0290	.94	330,000
May, . .	326,000	58	58½	-	Slight.	.41	.2560	.1145	5.97	1.2600	.0242	.66	103,500
June, . .	536,000	66	63	16m.	V. slight.	.39	.5790	.1633	10.22	1.2033	.0173	.81	117,166
July, . .	480,000	71	69	10m.	Decided.	1.31	1.2550	.2497	8.46	.8122	.0177	1.15	421,200
August, .	480,000	70	68	24m.	V. slight.	.54	.3336	.0992	9.42	1.4700	.0136	.56	70,800
September,	480,000	63	60	23m.	Decided.	.61	.3600	.1155	12.80	1.2825	.0600	.63	64,050
October, .	480,000	56	55½	1h. 30m.	Decided.	.46	.4350	.1240	9.56	1.5425	.0275	.65	132,000
November, .	480,000	45	48½	50m.	Decided.	.51	.5200	.1010	14.09	1.0925	.0362	.67	137,000
December, .	480,000	41	45	1h.	D ided.	.51	1.1500	.1784	6.06	.6440	.0116	.97	209,200

Sewage applied, 3 gallons 24 times a week, till March 15; 3 gallons 36 times a week, March 18 to May 13; 4 gallons 36 times a week, May 15 to June 10; 5 gallons 36 times a week, June 12 to 25; 4 gallons 36 times a week, June 26 to October 22; 2 gallons 72 times a week, October 23 to December 31. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 18 to 21. Air drawn through gravel from March 18 to July 10, and from July 15 to December 31. Surface raked 3 inches deep 4 times, July 28 to September 1, and each week from September 1 to October 26; 3 inches deep daily, October 26 to November 27, after which surface was raked from 6 to 10 inches deep, as follows: 6 inches deep on November 28, 29, 30, December 1, 2, 11, 15 and 16; 8 inches deep December 3 and 12; 10 inches deep December 8.

Effluent from Filter No. 16 B.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	240,000	48	41	-	Decided.	.72	.5750	.1425	7.14	.9725	.0869	.82	435,250
February, .	302,000	45½	41½	-	Decided.	.40	.3250	.1410	6.33	1.1575	.1740	.99	244,950
March, .	332,000	43	43	12m.	Slight.	.46	.5760	.1356	5.82	1.1000	.0074	.93	176,400
April, . .	360,000	45	46½	13m.	Slight.	.46	.3025	.1685	6.58	1.0525	.2659	1.03	222,500
May, . .	332,000	53	54	-	Slight.	.42	.2215	.1095	5.94	1.4200	.0096	.64	113,750
June, . .	536,000	66	63	16m.	V. slight.	.36	.3143	.1067	10.02	1.2250	.0049	.67	94,500
July, . .	480,000	71	70	9m.	Slight.	.37	.7229	.1797	8.30	1.5453	.0089	.83	69,714
August, .	480,000	70	68½	8m.	Slight.	.57	.4160	.1484	9.23	1.0900	.0682	.71	81,200
September,	480,000	63	60	13m.	Decided.	.36	.7225	.1490	11.91	.6300	.1900	.79	87,800
October, .	480,000	56	56	45m.	Decided.	.51	.5725	.1255	10.20	.8425	.0387	.63	157,250
November, .	480,000	45	47	4m.	Decided.	.57	.5725	.2455	15.55	.8700	.0447	1.26	277,750
December, .	480,000	41	44	37m.	Decided.	.45	1.1780	.2216	5.96	.5000	.0142	.99	168,200

Sewage applied, 3 gallons 24 times a week, till February 12; 3 gallons 36 times a week, February 13 to May 14; 4 gallons 36 times a week from May 15 to June 11; 5 gallons 36 times a week, June 12 to 25; 4 gallons 36 times a week, June 26 to October 22; 2 gallons 72 times a week from October 23 to December 31. Experiments interrupted by high water March 15 to 17; May 4 to 9; May 18 to 21; Air drawn through gravel January 16 to December 31. Surface raked 3 inches deep 4 times from July 18 to September 1 and each week from September 1 to October 26; 3 inches deep daily, October 26 to December 31, with the following exceptions: 8 inches deep, December 12, and 6 inches deep, December 30.

Filter No. 13.

This filter was used during the winter months for confirmation of experiments to determine the effect of nitrification upon the removal of bacteria by filtration. Beginning March 22 sewage was applied at the rate of 160,000 gallons per acre daily for six days in a week. This was done with a view to obtaining, in conjunction with Filter No. 14, some comparable results upon the removal of dyestuffs from sewage by filters of coarse sand with and without the presence of polarite. These results are summarized on page 427.

Effluent from Filter No. 13.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.			Bacteria per Cubic Centimeter.
January, . .	60,000	–	46	3m.	None.	.09	.(	6	12,740
February, . .	60,000	–	45½	3m.	None.	.06	.(	6	3,225
March, . .	90,000	43	45½	3m.	V. slight.	.09	.(	7	9,010
April, . .	160,000	46	49	6m.	V. slight.	.18	.(	0	67,000
May, . .	124,400	53	54	–	V. slight.	.14	.(	3	60,000
June, . .	160,000	66	64	4m.	V. slight.	.15	.(	4	54,000
July, . .	160,000	71	65	4m.	V. slight.	.16	.(	0	46,000
August, .	160,000	70	66	6m.	V. slight.	.18	.(	2	51,667
September, .	160,000	63	–	9m.	V. slight.	–	.(	4	22,900

Three gallons effluent from Filter No. 13 A applied, 6 times a week, till March 21. Eight gallons sewage applied, 6 times a week, March 22 to September 27. Forty-four hundredths parts per 100,000 of Scarlet 2R applied in sewage, August 26 to September 7. Sand washed September 9, by applying city water, to remove traces of Scarlet 2R, and 0.33 parts per 100,000 of Patent Blue applied in sewage, September 22–27. Experiment discontinued September 27.

Filter No. 13 A.

This filter contains 60 inches in depth of sand of an effective size of 0.19 millimeter, and was constructed on September 27, 1893. It has received the supernatant liquid from sewage which had been allowed to settle four hours. The surface, which has been scraped when necessary to relieve clogging and not raked, was scraped on an average once in six days, and the average depth removed was 0.37 inch. Owing to sub-surface clogging it was necessary to spade over the surface 6 inches deep three times in December. It appeared that the rate of filtration, 480,000 gallons per acre daily for six days in a week, overtaxed the capacity of the filter, which was allowed to rest for two weeks beginning December 23. The results are discussed on page 423.

Effluent from Filter No. 13 A.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
October, .	400,000	–	56	15m.	None.	.08	1.6725	.0650	[illegible]	.5925	.1775	.33	3,300
November, .	480,000	–	50	1h. 40m.	None.	.13	.8825	.0405	9.46	1.4500	.1450	.34	3,856
December, .	360,000	–	46	1h. 50m.	Slight.	.28	2.6900	.0670	6.25	.7300	.0475	.40	28,075

Sewage (settled 4 hours) applied, 6 gallons 16 times a week, September 27 to October 22; 8 gallons 48 times a week, October 23 to December 23, after which none was applied. Surface scraped and sand of previous scraping (after washing) replaced on following dates: October 9, 21, 27, November 1, 7, 13, 17, 24, 28, 30, December 5, 7, 18. Spaded over 6 to 7 inches deep, December 2, 12, 19.

Filter No. 14.

This filter is 63 inches deep and contains sand of an effective size of 0.48 millimeter. On January 21, 1893, the upper 6 inches of partially clogged and discolored sand were removed; the next 7 inches were taken out and, after putting in 7 inches in depth of polarite, were used to fill the filter to its original depth. The chief experiment was upon the removal of color from sewage containing dyestuffs, which is summarized on page 427.

The rate of filtration was 160,000 gallons per acre daily for six days in a week until October 23 when the rate was doubled. The quality of the effluent was uniformly good until the middle of November, when clogging occurred at the surface of the polarite. The filter was allowed to rest from November 16 to December 4, when sewage was again applied at the rate of 160,000 gallons. The effluent was well purified, but clogging began to gradually reappear.

Effluent from Filter No. 14.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	160,000	48	48	34m.	V.slight.	Slight blue.	.0071	.0363	6.44	1.7767	.0006	.37	32,667
February,	160,000	45½	44	7m.	None.	Slight green.	.0029	.0447	6.51	2.6025	.0003	.33	50,125
March, .	160,000	43	44	6m.	None.	Green.	.0042	.0347	5.23	3.0975	.0000	.28	18,075
April, .	160,000	45	47½	9m.	None.	Green.	.0044	.0335	5.86	3.2850	.0000	.26	18,250
May, .	124,400	53	54	–	None.	Green.	.0054	.0329	6.20	3.6940	.0000	.24	12,600
June, .	160,000	66	63½	10m.	None.	Green.	.0063	.0313	8.52	4.2325	.0002	.26	49,333
July, .	160,000	71	65	6m.	None.	Green.	.0079	.0433	8.38	3.7100	.0016	.26	60,000
August, .	160,000	70	65½	4m.	V.slight.	Slight blue.	.0039	.0376	7.85	2.3167	.0005	.22	71,333
September,	160,000	63	58½	8m.	V.slight.	Slight blue.	.0023	.0277	7.97	1.9800	.0002	.17	55,000
October, .	209,200	56	54	10m.	V.slight.	Slight blue.	.0018	.0326	7.69	1.6800	.0000	.18	45,000
November,	320,000	45	48	12h.	V.slight.	Slight blue.	.0150	.0327	16.06	0.9200	.0025	.20	23,667
December,	160,000	41	44½	2h.	None.	.10	.0025	.0208	5.69	2.9500	.0007	.17	22,500

Sewage applied, 8 gallons 6 times a week, till October 22; 8 gallons 12 times a week, October 23 to November 16; 8 gallons 6 times a week, December 4 to December 31. Color applied in sewage February 13 to March 22 and August 26 to September 28. Experiments interrupted by high water March 15 to 17; May 4 to 9; May 18 to 21. Surface raked 3 inches deep each week.

FILTER No. 17 A.

This filter of medium fine sand, with four layers of marble dust, received during the entire year sewage to which sulphuric acid equal to 49 parts in 100,000 of actual H_2SO_4 was added. The rate of filtration was 60,000 gallons per acre daily for six days in a week. The free ammonia in the effluent began to increase in November, 1892, and was unusually high during the greater part of 1893. This increase, as well as that of the albuminoid ammonia, was owing to an interruption in ventilation caused by clogging. To remedy this the upper layer of marble dust, about 3 inches below the surface, in July, and later the sand above this layer, were replaced with new materials. It was found that the original layer of marble dust had occasionally been disturbed in the weekly raking and this treatment gave only temporary relief. Clogging again occurred in September, nitrification was very incomplete, and there was present a reducing action, as the sand down to the second layer of marble dust (12 inches) was very black with iron sulphide. A thin layer was scraped from the surface of the second portion of marble dust in October and the old sand replaced. The quality of the effluent steadily improved and in December was excellent.

Effluent from Filter No. 17 A.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	60,000	48	44	3h.	None.	.10	.1320	.0175	9.57	2.1700	.0002	.51	38
February, .	60,000	45½	42	3h. 40m.	None.	.10	.0812	.0196	5.81	1.8250	.0004	.26	5
March, .	56,000	43	43	2h. 45m.	None.	.08	.2163	.0370	6.01	2.0200	.0002	.18	0
April, . .	60,000	45	46	6h. 40m.	None.	.16	.1771	.0254	5.93	2.4550	.0003	.22	4
May, . .	46,000	53	53	-	None.	.13	.0630	.0269	6.33	3.1667	.0005	.26	45
June, . .	60,000	66	64½	1h.	None.	.18	.4700	.0390	9.04	4.3450	.0028	.27	26
July, . .	60,000	71	70	1h.	V. slight.	.17	.1700	.0510	8.92	3.9250	.0028	.28	920
August, .	60,000	70	72	45m.	None.	.12	.0140	.0233	12.63	2.4750	.0015	.26	370
September,	60,000	63	62½	12h.	V. slight.	.13	.2185	.0310	12.73	1.0050	.0043	.25	124
October, .	60,000	56	59½	12h.	V. slight.	.15	1.6500	.0690	7.72	.5200	.0185	.36	1,670
November, .	60,000	45	48½	2h. 40m.	None.	.13	.1365	.0406	8.67	3.6250	.0061	.28	815
December, .	60,000	41	42	2h. 35m.	None.	.09	.0022	.0149	6.52	2.4800	.0008	.18	302

Three gallons of sewage plus sulphuric acid equal to 49 parts per 100,000 applied 6 times a week. Surface raked 3 inches deep each week. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 17 to 21. July 12, upper layer of marble dust replaced by a fresh layer. August 16, upper 3 inches of sand replaced by fresh sand. September 29, upper layer of marble dust disturbed. October 21, marble dust and upper 3 inches of sand removed. October 25, 9 inches of sand removed and second layer of marble dust scraped; sand replaced with 3 inches of clean material.

FILTER No. 19.

This filter of medium fine sand has received since January 20, 1893, the supernatant liquid from sewage which was allowed to settle for four hours after treatment with alum at the rate of 1,000 pounds per million gallons. The rate of filtration was 120,000 gallons per acre daily for six days in a week up to June 12, after which the rate was increased from time to time until it became 640,000 gallons on and after October 23. From April to August, inclusive, the quality of the effluent was excellent, but the ammonias began to increase in September and continued to do so during the rest of the year. Since October 23 the surface has been scraped to relieve clogging. It has been scraped on an average once in ten days, and the average depth removed was 0.47 inch. On December 2 and 12 the surface was spaded over, 6 inches deep, to relieve clogging. This clogging and the deterioration in the quality of the effluent indicated that this high rate of filtration when long continued overtaxed the capacity of the filter which was allowed to rest for two weeks beginning December 23. See page 422 for a discussion of these results.

Effluent from Filter No. 19.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F. Sewage.	Temperature. Deg. F. Effluent.	Length of Time. Sewage Remained on Surface. — Hours and Minutes.	Appearance. Turbidity.	Appearance. Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Bacteria per Cubic Centimeter.
January, .	74,000	-	41½	1h.	None.	.37	.2828	.0279	8.59	1.1500	.0044	.39	51,773
February, .	120,000	-	43	10m.	None.	.18	.9900	.0400	7.69	1.1600	.0600	.33	17,262
March, .	110,000	-	41	11m.	None.	.08	.1661	.0255	5.25	2.0900	.0440	.23	5,467
April, .	120,000	-	45½	10m.	None.	.11	.0066	.0156	5.66	2.1700	.0008	.18	545
May, . .	94,000	-	53	-	None.	.11	.0083	.0237	6.01	2.5000	.0005	.15	495
June, . .	146,000	-	63	12m.	V. slight.	.12	.0057	.0200	9.95	2.1620	.0002	.18	594
July, . .	160,000	-	67	12m.	None.	.08	.0062	.0216	8.42	3.3900	.0002	.18	870
August, .	240,000	-	68	9m.	None.	.08	.0028	.0174	7.34	1.8060	.0000	.15	217
September,	480,000	-	66	33m.	None.	.07	.0609	.0192	6.63	2.3550	.0055	.15	432
October, .	530,000	-	56	45m.	V. slight.	.13	.7691	.0507	10.30	1.8125	.0026	.27	3,122
November, .	640,000	-	46	1h. 40m.	V. slight.	.18	1.7200	.0585	10.07	1.7625	.0109	.30	1,545
December, .	492,000	-	41½	2h.	Slight.	.21	2.3800	.0890	6.32	.8600	.0033	.49	6,695

Six gallons of chemically clarified sewage applied 6 times a week, till June 11; 8 gallons 6 times a week, June 12 to July 30; 6 gallons 12 times a week, July 31 to August 31; 4 gallons 36 times a week, September 1 to October 22; 4 gallons 48 times a week, October 23 to December 23, after which none was applied. Experiments interrupted by high water March 15 to 17, May 4 to 9, May 18 to 21. Surface raked 3 inches deep each week until October 23, after which surface was scraped and sand of previous scraping (after washing) replaced on following dates: November 3, 13, 18, 22, 28. Spaded, 6 inches deep, December 2, 12. October 6, upper 4 inches removed and replaced with fresh sand.

Filter No. 25.

In this filter was buried on December 18, 1889, the carcass of a dog above 5 feet of sand and loam and beneath 6 feet of sand, loam and soil, as was described in the Special Report upon the Purification of Sewage and Water (page 689). Since May 9, 1892, city water has been applied at the rate of 60,000 gallons per acre daily for six days in a week. There was a marked improvement in the chemical quality of the effluent in 1892, but the numbers of bacteria increased. In 1893 there have been no marked changes in the chemical characteristics of the effluent, and while the numbers of bacteria have been quite variable, they have averaged considerably lower than during the latter part of the preceding year. The effluent has been uniformly discolored by iron. The odor and turbidity have been very much less marked than formerly, but are still perceptible.

Effluent from Filter No. 25.

[Parts per 100,000.]

	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Free.	Albuminoid.		Nitrates.	Nitrites.		
1892.								
January,	10,000	4.2500	.0700	.25	.130	.0180	.28	0
February,	10,000	3.6500	.1000	.30	.060	.0060	.18	0
March,	10,000	2.2000	.0660	.25	.050	.0060	.46	0
April,	10,000	3.6000	.0460	.30	.080	.0150	.09	0
May,	46,000	2.8000	.0605	.23	.060	.0055	.30	6
June,	60,000	1.2333	.0827	.16	.020	.0067	.11	4
July,	60,000	.8750	.0310	.16	.010	.0040	.11	10
August,	60,000	.8200	.0260	.19	.010	.0018	.13	175,000
September,	60,000	.7000	.0380	.35	.010	.0000	.15	23,400
October,	60,000	.5300	.0160	.22	.000	.0004	.10	20,000
November,	60,000	.3400	.0260	.29	.010	.0004	.09	25,000
December,	60,000	.2700	.0180	.24	.005	.0010	.02	40,000
1893.								
January,	60,000	.2700	.0080	.22	.010	.0012	.15	2,000
February,	60,000	.3500	.0180	.30	.015	.0014	.26	3,000
March,	58,000	.3000	.0100	.27	.022	.0036	.09	1,240
April,	60,000	.2900	.0220	.22	.019	.0000	.26	1,200
May,	40,000	.3450	.0260	.12	.021	.0007	.16	200
June,	60,000	.3800	.0320	.19	.094	.0020	.12	2
July,	60,000	.3700	.0260	.20	.040	.0018	.13	9
August,	60,000	.3300	.0180	.22	.005	.0030	.17	600
September,	60,000	.2600	.0180	.22	.009	.0020	.08	6
October,	60,000	.2200	.0240	.23	.007	.0030	.09	2,220
November,	60,000	-	-	-	-	-	-	-
December,	65,000	.2500	.0170	.20	.012	.0045	.05	675

Outlet pipe trapped. City water applied in 3 gallon doses once a week until May 9, 1892, and since that time 6 times a week. Experiment interrupted by high water March 15 to 17, May 4 to 9 and May 18 to 22, 1893. Surface scraped July 10, 1893. The applied water froze on the surface several times during the severest winter weather and was removed.

Filter No. 30.

This filter contains 30 inches in depth of coarse sand of an effective size of 0.48 millimeter. It has received sewage at a uniform rate of 55,800 gallons per acre daily for six days in a week with satisfactory results. No disturbance of the material, other than the weekly raking, has taken place since the filter was first put in operation, May 31, 1890.

Effluent from Filter No. 30.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	55,800	48	40½	2m.	Slight.	.46	.0561	.0590	6.16	2.0300	.0022	.45	20,231
February, .	55,800	45½	43½	3m.	V. slight.	1.92	.0265	.0566	6.02	2.2100	.0007	.46	60,500
March, . .	55,800	43	40	2m.	V. slight.	.38	.0510	.0549	5.35	2.6700	.0007	.38	28,500
April, . .	55,800	45	43½	2m.	V. slight.	.30	.0560	.0492	6.87	2.7150	.0006	.35	13,500
May, . .	47,500	53	54	-	V. slight.	.26	.0714	.0602	6.13	3.0000	.0019	.32	53,333
June, . .	55,800	66	64½	1m.	V. slight.	.26	.1440	.0710	12.89	4.0650	.0032	.38	32,000
July, . .	55,800	71	70	1m.	V. slight.	.31	.1800	.0940	8.67	5.0250	.0100	.47	3,500
August, .	55,800	70	70½	1m.	V. slight.	.34	.0670	.0670	8.92	2.8050	.0075	.33	8,000
September, .	55,800	63	65½	2m.	Decided.	.41	.1060	.0680	11.90	2.2050	.0012	.38	12,900
October, .	55,800	56	56½	2m.	Slight.	.50	.1360	.0450	8.19	2.6000	.0045	.41	50,700
November, .	55,800	45	47	28m.	Slight.	.28	.0620	.0480	23.60	2.1600	.0020	.28	23,000
December, .	55,800	41	39½	10m.	Decided.	.28	.2400	.0760	6.42	2.3500	.0030	.47	47,000

Sewage applied, 2 gallons 6 times a week. Surface raked 3 inches deep each week. Experiments interrupted by high water May 4 to 8; May 18 to 20.

FILTER No. 31.

This filter contains 30 inches in depth of medium fine sand of an effective size of 0.17 millimeter. It has received sewage at a uniform rate of 55,800 gallons per acre daily for six days in a week. The effluent has been uniformly well purified. No disturbance of the material, other than the weekly raking, has taken place since the filter was first put in operation May 31, 1890.

Effluent from Filter No. 31.

[Parts per 100,000.]

1892.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	55,800	48	41	12m.	None.	.20	.0356	.0235	6.89	2.5400	.0004	.24	950
February, .	55,800	45½	41½	16m.	None.	-	.0181	.0278	6.44	2.1900	.0003	.23	1,160
March, . .	55,800	43	41½	18m.	None.	.09	.0175	.0213	5.18	2.2650	.0001	.22	475
April, . .	55,800	45	44	15m.	None.	.17	.0049	.0226	5.97	2.5050	.0000	.24	172
May, . .	47,500	53	53½	-	None.	.15	.0147	.0213	6.30	3.2433	.0005	.20	677
June, . .	55,800	66	64½	5m.	None.	.14	.0118	.0217	6.46	3.9500	.0003	.24	375
July, . .	55,800	71	71	6m.	V. slight.	.17	.0301	.0242	8.54	4.2900	.0006	.18	315
August, .	55,800	70	71	9m.	V. slight.	.20	.0084	.0167	10.79	3.3900	.0005	.17	50
September. .	55,800	63	65	40m.	V. slight.	.15	.0070	.0206	12.60	2.3200	.0002	.18	90
October, .	55,800	56	57	32m.	V. slight.	.21	.0310	.0256	8.16	2.7000	.0014	.25	1,384
November, .	55,800	45	46½	3h. 30m.	V. slight.	.21	.0122	.0244	17.10	2.2400	.0002	.19	360
December, .	55,800	41	39	12h.	None.	.20	.0248	.0302	7.25	2.0000	.0006	.28	400

Sewage applied, 2 gallons 6 times a week. Surface raked 3 inches deep each week. Experiments interrupted by high water May 5 to 8; May 18 to 20.

Filter No. 32.

This filter contains 30 inches in depth of medium fine sand of an effective size of 0.17 millimeter. It received the supernatant liquid from sewage treated by chemical precipitation like that applied to No. 19 at the rate of 112,000 gallons per acre daily for six days in a week. This rate was doubled on June 12 and that rate doubled October 23 (446,000 gallons). The filter became clogged in spite of frequent raking and scraping; this, with the deterioration in the quality of the effluent, indicated that this rate of filtration overtaxed the capacity of the filter, which was allowed to rest for two weeks beginning December 23.

Effluent from Filter No. 32.

[Parts per 100,000.]

1893.	Quantity Applied. — Gallons per Acre Daily for Six Days in a Week.	Temperature. Deg. F.		Length of Time Sewage Remained on Surface. — Hours and Minutes.	Appearance.		Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Bacteria per Cubic Centimeter.
		Sewage.	Effluent.		Turbidity.	Color.	Free.	Albuminoid.		Nitrates.	Nitrites.		
January, .	111,600	-	40	1h. 30m.	None.	.17	.0031	.0232	4.94	1.7100	.0001	.27	504
February, .	111,600	-	41	1h.	None.	.14	.0096	.0194	4.63	1.3325	.0006	.28	1,560
March, . .	111,600	-	41	1h. 30m.	None.	.09	.1711	.0260	4.79	1.9040	.0003	.22	1,330
April, . .	111,600	-	46	1h.	None.	.13	.1350	.0365	6.30	1.9075	.0000	.20	4,500
May, . .	95,000	-	55	-	None.	.14	.0526	.0280	5.76	2.3250	.0001	.18	6,625
June, . .	186,800	-	65	50m.	None.	.13	.0461	.0372	13.19	1.8980	.0000	.19	2,328
July, . .	223,200	-	70	45m.	None.	.16	.0067	.0236	8.70	1.1850	.0000	.24	274
August, .	223,200	-	70	50m.	None.	.13	.0060	.0224	7.36	1.0040	.0000	.25	175
September, .	223,200	-	62	2h. 45m.	None.	.11	.0179	.0195	6.72	1.0525	.0006	.16	46
October, .	291,900	-	56½	2h.	None.	.11	.3704	.0377	10.75	1.5867	.0018	.19	5,833
November, .	446,400	-	46	1h. 50m.	None.	.23	1.7733	.0733	9.43	1.2467	.0049	.35	15,713
December, .	343,200	-	39½	1h. 50m.	None.	.17	1.2875	.0550	5.99	1.4150	.0032	.31	3,770

Surface raked 3 inches deep each week until October 21. Experiments interrupted by high water May 5 to 8; May 18 to 20. Four gallons chemically clarified sewage applied, 6 times a week, till June 11; 2 gallons 24 times a week, June 12 to October 22; 2 gallons 48 times a week, October 23 to December 23, after which none was applied. Surface spaded 6 inches deep, November 20, December 12 and December 21. Surface scraped, and sand of previous scraping replaced (after washing) on following dates: October 21, November 7, 17, 24, 29, December 2, 18 and 21.

FILTRATION OF WATER.

One of the chief objects of water filtration, in most cases, is a removal of the disease-producing germs. The investigations by the Board in 1892 indicated that it is possible to construct filters which will yield 2,000,000 gallons of water per acre daily, and remove 99.5 per cent. of the bacteria in the applied water. The investigations were continued in 1893 with the view to learn the efficiency of the filters as they continued in service, and also to learn the bacterial efficiency of filters of coarser sands operated at higher rates of filtration.

The general plan of the experiments was the same as in 1892. Examination of the bacterial contents of the river water and of the effluent of each filter were made daily throughout the year. Owing to complications from freezing, which caused the formation of channels at the sides of the iron filter tanks during the winter months, and to the evolution of air by the saturated water within the filters, the results obtained from May to November, inclusive, alone will be discussed. Beginning May 12 *B. prodigiosus* was regularly applied to the filters ten hours daily and the effluent of each filter examined four or more times daily, at the time when the applied water containing this germ is passing through the outlet pipes. The reason that this germ was used is because it is easy to differentiate it from ordinary water bacteria and in its mode of life in the river water it appears to be very similar to the germ generally recognized as the cause of typhoid fever. In the table below is given a summary of the results obtained from the several filters. In the case of the older filters (Nos. 18 A to 42) the averages include all of the results; in the case of the remaining (new) filters the averages include all results after the second week of operation, when the efficiency in most cases became normal. The diameter of all of these filters is twenty inches and the area of filtering surface is equal to one twenty-thousandth of an acre. A detailed account of these results will be found beyond.

Summary of Bacterial Results obtained from the Several Water Filters, May 12 to Dec. 2, 1893.

Depth of Material. (Inches.)	Average Rate of Filtration. Gallons per Acre Daily.	Average Per Cent. of Number of Applied Bacteria which appeared in Effluent. Water Bacteria.	Bacillus Prodigiosus.
60	1,880,000	3.26	0.461
60	2,160,000	1.00	0.036
45	1,580,000	0.56	0.023
48	1,600,000	0.44	0.049
48	1,880,000	1.46	0.064
55	2,420,000	0.31	0.010
20	2,220,000	0.98	0.061
1	1,660,000	4.06	0.782
60	1,640,000	0.43	0.039
10	1,860,000	0.90	0.060
60	4,848,000	1.07	0.069
60	4,940,000	0.60	0.068
60	2,220,000	2.26	0.290
12	2,400,000	0.99	0.169
60	2,580,000	3.41	0.436
60	2,280,000	3.52	0.501
40	3,800,000	0.31	0.160

The results show that —

1. The bacterial efficiency of the older filters, all things considered, was as satisfactory in 1893 as it was during the preceding year.

2. A high degree of bacterial efficiency was attained by the new filters of coarser sand and operated at higher rates of filtration.

This is brought out more clearly by the following table, in which are summarized the results obtained from the newer and coarser filters for the four weeks ending December 2. The bacterial averages include the results of all examinations in each case and represent at least four samples daily taken at widely different hours.

Summary of Bacterial Results obtained from Filters Nos. 43–49, with Rates of Filtration, November 6 to Dec. 2, 1893.

Number of Filter.	Depth of Material. — Inches.	Method of Operation.	Average Rate of Filtration. — Gallons per Acre Daily.	Average Per Cent. of Number of Applied Bacteria which appeared in the Effluent.	
				Water Bacteria.	Bacillus Prodigiosus.
43, ...	60	Continuous.	7,660,000	1.48	0.171
44, ...	60	Continuous.	7,700,000	1.19	0.148
45, ...	60	Intermittent.	3,740,000 [6,540,000]	1.50	0.210
46, ...	12	Continuous.	3,700,000	2.34	0.337
47, ...	60	Intermittent.	3,660,000 [6,405,000]	3.13	0.463
48, ...	60	Intermittent.	2,900,000 [5,075,000]	1.83	0.366
49, ...	60	Continuous.	5,550,000	1.04	0.183

The rates of filtration enclosed within the brackets are for the time when water was actually applied; the other rates are averages for the whole time, including the periods of rest.

These figures show that very good results were obtained from the newer experimental filters which were operated at much higher rates of filtration than those studied in 1892. This is particularly the case with Filters Nos. 43 and 44, which during the latter part of November were operated at rates of more than 9,000,000 gallons per acre daily, with a removal of over 98 per cent. of the applied water bacteria and over 99.5 per cent. of the applied *B. prodigiosus*.

THE EFFECT UPON BACTERIAL PURIFICATION OF RATE OF FILTRATION OF WATER.

There are two views to this problem, first, the effect of differences in rates of filtration where the rate is kept constant after the change has once been made; and, second, the effect of fluctuating rates.

It is thought that the effect of changes in rates, which are regularly maintained after the change is made, is best shown by taking the average monthly results. The rates of filtration of the several filters were very seldom changed more than once in a month; they were not changed at all in some instances and all changes were moderate ones. When we consider the large number of bacteria stored in the sand the small differences in the number of bacteria in the applied water exert usually but little influence upon the numbers in the effluent and the results are therefore expressed in numbers per cubic centimeter.

Average Monthly Results, showing the Number of Bacteria per Cubic Centimeter in the Effluents of the several Water Filters.

[Rates expressed in million gallons per acre daily.]

Number of Filter.	Method of Operation.	May.			June.			July.			August.			September.			October.			November.		
		Rate.	Water Bacteria.	Bacillus Prodigiosus.	Rate.	Water Bacteria.	Bacillus Prodigiosus.	Rate.	Water Bacteria.	Bacillus Prodigiosus.	Rate.	Water Bacteria.	Bacillus Prodigiosus.	Rate.	Water Bacteria.	Bacillus Prodigiosus.	Rate.	Water Bacteria.	Bacillus Prodigiosus.	Rate.	Water Bacteria.	Bacillus Prodigiosus.
18 A,	Intermittent.	1.5	24	-	2.3	18	-	1.7	222	58.0	1.9	148	29.0	1.7	2,375	19.5	1.6	1,002	52.0	1.8	167	11.5
33 A,	Continuous.	1.7	8	0.7	1.7	15	0.7	1.9	98	2.5	2.7	107	2.2	1.9	53	2.0	1.9	39	0.3	2.8	29	0.9
34 A,	Continuous.	1.6	9	1.7	1.4	12	0.8	1.9	24	1.2	2.3	39	1.6	-	-	-	-	-	-	-	-	-
35 A,	{ Intermittent. / Continuous. }	1.4	17	-	1.2	9	1.9	1.7	53	5.0	3.0	22	3.6	-	-	-	-	-	-	-	-	-
36 A,	{ Continuous. / Intermittent }	2.0	10	-	2.0	12	0.3	3.0	107	6.0	1.7	157	3.8	-	-	-	-	-	-	-	-	-
37,	Continuous.	1.7	7	0.0	3.4	13	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38,	Continuous.	1.9	12	1.3	1.7	17	1.2	1.9	127	5.0	2.5	84	3.3	1.9	22	0.7	2.0	29	0.1	3.4	58	4.5
39,	{ Continuous. / Intermittent. }	2.0	19	4.0	1.6	35	9.0	1.5	352	82.0	1.7	318	89.0	-	-	-	-	-	-	-	-	-
41,	Intermittent.	2.0	9	1.5	1.5	10	1.5	2.0	33	4.4	1.9	39	5.4	1.9	48	2.9	1.8	19	0.5	1.6	10	0.3
42,	Continuous.	1.9	9	1.5	1.7	10	1.5	1.9	117	5.5	1.9	55	2.8	1.8	22	2.8	2.0	13	1.4	1.9	78	7.0
43,	Continuous.	2.2	1,042	53.0	3.9	316	6.0	2.8	72	5.5	4.3	26	5.0	4.5	57	2.4	4.8	46	8.4	7.6	124	11.0
44,	Continuous.	2.2	318	57.0	2.8	128	12.0	2.8	29	7.0	4.3	29	6.0	4.7	53	1.3	5.8	22	1.9	7.6	96	9.0
45,	Intermittent.	-	-	-	-	-	-	1.5	680	92.0	1.9	92	25.0	1.7	725	8.5	1.8	39	12.0	3.6	119	12.0
46,	Continuous.	-	-	-	-	-	-	-	-	-	2.0	65	1.3	1.9	98	3.3	2.3	41	18.0	3.6	171	17.0
47,	Intermittent.	-	-	-	-	-	-	-	-	-	-	-	-	1.7	2,296	176.0	1.8	598	18.0	3.6	213	25.0
48,	Intermittent.	-	-	-	-	-	-	-	-	-	-	-	-	1.8	3,060	136.0	1.8	663	33.0	2.9	123	23.0
49,	Continuous.	-	-	-	-	-	-	-	-	-	-	-	-	2.1	344	19.0	2.6	112	7.0	5.3	72	12.0

In the case of No. 18 A the number of bacteria in the effluent increased about the middle of July after removing the siphon which delivered the water in one-quart doses onto the sand about once in four minutes days, nights and Sundays. After this time the water was applied sixteen hours a day and the filter allowed to drain during the remaining hours. Some of the bacterial increases during the summer were due to growths or to conditions favoring longer continuance of life of the bacteria in the sand. This was more marked in continuous than in intermittent filters.

In some cases there were marked increases in the number of bacteria in the effluent, evidently not due to changes in rates of filtration, and which at present cannot be fully accounted for. In other instances, such as Nos. 43 and 44, an increase in the rate was followed at times by no increase whatever in the number of bacteria in the effluent; and, when studied by weeks, some of the results indicate a diminution. These results, taken all together, indicate that in the process of water filtration there exist conditions which exert more influence upon the bacterial contents of the effluent than do differences in rates of filtration within moderate limits. Some of the conditions appear to be normal to the operations of these experimental filters while others are not yet understood. Upon examination of the results obtained at the highest rates, however, it will be seen that the bacterial efficiency diminishes and the statement made in earlier reports that low rates are safer than high rates is undoubtedly true. Nevertheless, up to a certain limit the rate apparently exerts very little influence, and this limit is different for different filters and also varies with other conditions in the case of the same filter.

The Immediate Effect upon Bacterial Purification of Increasing the Rate of Filtration.

In the next table are given the results obtained from each filter with regard to this point. Fluctuations in the rate of filtration appear to be an important feature in the operation of some of the older filters in Europe and the following results have been obtained at the Experiment Station upon this subject. The number of bacteria per cubic centimeter for each of the three days before and the three days after increasing the rate of filtration are given in each case where there was no complication such as the effect of scraping. In most cases the rate was increased and practically no information has

been obtained as to the effect of decreasing the rate. As the changes were usually made on Monday there are very few results for the first day before increasing the rate.

Number of Bacteria per Cubic Centimeter.

Number of Filter.	Date. 1893.	Change in Rate. Million Gallons per Acre Daily.	Water Bacteria. Before increasing rate. Third Day.	Water Bacteria. Before increasing rate. Second Day.	Water Bacteria. Before increasing rate. First Day.	Water Bacteria. After increasing rate. First Day.	Water Bacteria. After increasing rate. Second Day.	Water Bacteria. After increasing rate. Third Day.	Bacillus Prodigiosus. Before increasing rate. Third Day.	Bacillus Prodigiosus. Before increasing rate. Second Day.	Bacillus Prodigiosus. Before increasing rate. First Day.	Bacillus Prodigiosus. After increasing rate. First Day.	Bacillus Prodigiosus. After increasing rate. Second Day.	Bacillus Prodigiosus. After increasing rate. Third Day.
33 A, .	June 1,	2-3	3	4	8	19	13	10	0.8	0.2	0.3	0.5	3.0	3.0
	July 31,	2-3	278	117	-	95	39	105	1.0	2.0	-	10.0	4.0	4.0
	Nov. 6,	2-3	9	18	-	21	15	24	0.0	0.0	-	0.7	0.0	0.7
	Nov. 27,	3-4	20	17	-	83	59	36	2.0	0.6	-	2.0	3.0	5.0
Avs.,	. .	. .	77	39	-	55	32	44	0.9	0.7	-	3.3	2.5	3.2
36 A, .	June 1,	2-3	-	5	4	6	22	36	-	-	-	-	-	-
	July 3,	1.5-3	45	56	-	185	83	18	0.8	0.0	-	5.0	0.5	-
Avs.,	. .	. .	45	30	-	95	52	27	0.8	0.0	-	5.0	0.5	-
38, .	June 1,	2-3	5	10	7	24	15	10	0.8	0.2	0.5	0.5	-	0.2
	July 3,	1-2	87	69	-	49	14	8	1.0	1.0	-	4.0	2.0	4.0
Avs.,	. .	. .	46	40	-	36	15	9	0.9	0.6	-	2.3	2.0	2.1
41, .	July 3,	1-2	11	8	-	28	8	9	0.0	1.0	-	3.0	2.0	1.0
42, .	June 1,	2-3	10	9	-	16	13	10	0.8	0.5	-	2.0	1.0	1.0
	July 3,	1-2	19	22	-	14	10	-	3.0	3.0	-	7.0	4.0	-
Avs.,	. .	. .	15	15	-	15	12	10	1.9	1.7	-	4.5	2.5	1.0
43, .	Aug. 21,	4-5	14	49	-	11	7	12	4.0	13.0	-	5.0	3.0	11.0
	Oct. 25,	5-6	-	-	36	44	197	84	-	-	19.0	14.0	44.0	31.0
Avs.,	. .	. .	14	49	36	27	102	48	4.0	13.0	-	10.0	23.0	22.0
44, .	Aug. 21,	4-5	29	23	-	11	4	-	4.0	4.0	-	11.0	3.0	-
	Oct. 25,	5-6	13	-	34	19	18	14	0.3	-	1.0	8.0	4.0	3.0
Avs.,	. .	. .	21	23	34	15	11	14	2.1	4.0	-	9.5	3.5	3.0
45, .	Nov. 6,	3-4	47	30	-	300	115	81	9.0	5.0	-	6.0	-	16.0
	Nov. 20,	4-6	35	32	-	115	80	-	3.0	4.0	-	15.0	19.0	28.0
Avs.,	. .	. .	42	31	-	208	97	81	6.0	4.5	-	10.5	19.0	22.0
46, .	Oct. 23,	2-3	25	18	-	13	14	24	3.0	4.0	-	5.0	4.0	3.0

Number of Bacteria per Cubic Centimeter — Concluded.

Number of Filter.	Date. 1893.	Change in Rate. Million Gallons per Acre Daily.	Water Bacteria. Before increasing rate. Third Day.	Second Day.	First Day.	Water Bacteria. After increasing rate. First Day.	Second Day.	Third Day.	Bacillus Prodigiosus. Before increasing rate. Third Day.	Second Day.	First Day.	Bacillus Prodigiosus. After increasing rate. First Day.	Second Day.	Third Day.
47, .	Nov. 6,	2-4	53	31	-	294	277	176	23.0	12.0	-	-	9.0	23.0
	Nov. 20,	4-6	178	126	-	567	450	1,144	25.0	22.0	-	49.0	60.0	67.0
Avs.,	. .	. .	115	78	-	380	363	660	24.0	17.0	-	49.0	34.0	45.0
48, .	Nov. 6,	2-4	31	21	-	366	262	190	13.0	7.0	-	15.0	15.0	32.0
	Nov. 20,	4-6	245	143	-	135	53	154	31.0	36.0	-	49.0	19.0	10.0
Avs.,	. .	. .	138	82	-	250	157	172	22.0	22.0	-	32.0	17.0	21.0

Summary of Bacterial Results to show the Immediate Effect of Increasing the Rate of Filtration.

Number of Filter.	Water Bacteria. Before increasing rate. Third Day.	Second Day.	First Day.	Water Bacteria. After increasing rate. First Day.	Second Day.	Third Day.	Bacillus Prodigiosus. Before increasing rate. Third Day.	Second Day.	First Day.	Bacillus Prodigiosus. After increasing rate. First Day.	Second Day.	Third Day.
33 A, . . .	77	39	-	55	32	44	0.9	0.7	-	3.3	2.5	3.2
36 A, ...	45	30	-	95	52	27	0.8	0.0	-	5.0	0.5	-
38, ...	46	40	-	36	15	9	0.9	0.6	-	2.3	2.0	2.1
41, ...	11	8	-	28	8	9	0.0	1.0	-	3.0	2.0	1.0
42, ...	15	15	-	15	12	10	1.9	1.7	-	4.5	2.5	1.0
43, ...	14	49	36	27	102	48	4.0	13.0	-	10.0	23.0	22.0
44, ...	21	23	34	15	11	14	2.1	4.0	-	9.5	3.5	3.0
45, ...	42	31	-	208	97	81	6.0	4.5	-	10.5	19.0	28.0
46, ...	25	18	-	13	14	24	3.0	4.0	-	5.0	4.0	3.0
47, ...	115	78	-	380	363	660	24.0	17.0	-	49.0	34.0	45.0
48, ...	138	82	-	250	157	172	22.0	22.0	-	32.0	17.0	21.0
Averages, . .	49	37	-	102	78	100	6.0	6.4	-	12.2	10.0	12.9

These results show that in a majority of cases an increase in the number of bacteria in the effluent followed an increase, within these limits, in the rate of filtration. This is more noticeable in filters of coarse material than in those of fine, and shows an advantage of uniformity in the operation of water filters.

The Effect of Depth of Material upon Bacterial Purification of Water.

The results upon this point are as follows: —

Number of Filter.	Depth. — Inches.	Effective Size of Grain. — Millimeter.	Period — 1893.	Rate. — Million Gallons per Acre Daily.	Average Per Cent. of Number of Applied Bacteria which appeared in the Effluents.	
					Water Bacteria.	Bacillus Prodigiosus.
44, ...	60	0.29	May 20 to Dec. 2,	4.9	0.60	0.083
46, ...	12	0.29	Aug. 21 to Dec. 2,	2.5	0.99	0.169
44, ...	60	0.29	Nov. 6 to Dec. 2,	7.7	1.19	0.148
46, ...	12	0.29	Nov. 6 to Dec. 2,	3.7	2.34	0.337
37, ...	56	0.20	May 12 to June 25,	2.4	0.31	0.010
38, ...	20	0.20	May 12 to Dec. 2,	2.2	0.96	0.061
39, ...	1	0.20	May 12 to Aug. 19,	1.7	4.06	0.762
42, ...	10	0.20	May 12 to Dec. 2,	1.9	0.90	0.050

The results obtained from Filters Nos. 44 and 46 show that the deeper filter is the more effective, although the filter one foot deep gave quite satisfactory results, especially at the lower rate of filtration. Upon consideration of the second series it is seen that No. 37, the deepest filter, was the most effective while the shallowest one, No. 39, was the least efficient in removing bacteria. No. 39 contained 5 inches of underdrain (stones, gravel and coarse sand) in addition to the inch of sand. Of the two filters, Nos. 38 and 42, 20 and 10 inches deep, respectively, the shallower was very slightly the more efficient. It is to be noted that when the filters were restored to their original depth, by the addition in some cases of a foot of sand, there was no apparent effect upon the bacterial contents of the effluents. We must conclude, however, all things considered, that while very satisfactory results may be obtained, under favorable conditions, from filters one to two feet deep, the deeper filters are safer than the shallower ones.

The Effect of Size of Sand Grains upon Bacterial Purification.

In the following table is given a summary of the results obtained from the several filters during the month of November, this month affording the fairest comparison because the conditions were then most nearly alike.

Continuous Filters.

Number of Filter.	Effective Size of Grain. — Millimeter.	Estimated Maximum Rate. — Million Gallons per Acre Daily.	Average Rate. — Million Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluents. Water Bacteria.	B. Prodigiosus.
33 A,	0.14	16	2.8	29	1
38 (2 feet),	0.20	32	3.4	58	5
43,	0.26	53	7.6	124	11
44,	0.29	67	7.6	96	9
49,	0.38	116	5.3	72	12

Intermittent Filters.

Number of Filter.	Effective Size of Grain. — Millimeter.	Estimated Maximum Rate. — Million Gallons per Acre Daily.	Average Rate. — Million Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Effluents. Water Bacteria.	B. Prodigiosus.
41,	0.14	16	1.6	10	1
45,	0.23	42	3.6	120	12
47,	0.29	67	3.6	213	25
48,	0.38	116	2.9	123	23
18 A,	0.48	184	1.8	167	11

These results indicate that, within the limits in sizes of sand grains which would be ordinarily employed in filtration, the finer sands are slightly more efficient in removing bacteria than the coarser ones. It appears, however, that there are conditions sometimes attending the process of filtration which disguise and at times completely offset the slight advantages which arise from fineness of material.

The Effect of Scraping Filters upon Bacterial Purification of Water.

It was shown in the Annual Report for 1892 that there was a slight increase in the number of bacteria in the effluent after a filter had been scraped. The method of scraping the continuous filters followed

in 1892 was practised in 1893 until November 1, as follows: the water above the sand was siphoned off and the filter allowed to drain until the water stood about an inch below the surface of the sand. The outlet was then closed, the surface scraped and water applied slowly from the top. The intermittent filters were scraped after draining. In the table below is given a summary, up to November, of the number of bacteria in the effluent during each of the three days before and three days after scraping, and also of the remaining days of each period between scrapings. In some instances the filters were scraped about once a week and nearly all of the results are contained under the headings, three days before and three days after scraping; under these circumstances a representative result for the time midway between scrapings is given under the column, remaining days.

Summary of the Average Results of the Number of Bacteria per Cubic Centimeter in the Effluent of each Filter during Different Portions of each Period between Scrapings.

Number of Filter.	Maximum Loss of Head. Inches.	Number of Times Scraped.	Water Bacteria.							Bacillus Prodigiosus.						
			Remaining Days.	Before Scraping.			After Scraping.			Remaining Days.	Before Scraping.			After Scraping.		
				Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.		Third Day.	Second Day.	First Day.	First Day.	Second Day	Third Day.
33 A, . .	70	7	85	39	101	51	84	56	60	1.4	1.8	0.4	0.7	1.0	2.2	2.4
34 A, . .	70	17	18	21	13	33	39	16	18	1.5	1.5	2.2	1.4	1.6	1.0	1.4
35 A, . .	70	8	23	36	7	25	26	79	40	2.5	0.1	0.0	0.0	6.0	5.0	5.0
36 A, . .	70	6	104	110	64	103	91	104	39	6.0	1.5	3.9	1.8	2.8	1.8	3.9
38, . . .	35	16	64	74	50	67	48	42	35	2.1	2.0	2.2	2.5	4.1	1.9	2.7
39, . . .	23	11	182	167	125	244	265	263	212	40.0	42.2	52.4	56.7	60.0	90.0	24.0
41, . . .	70	5	22	10	15	30	59	52	146	2.9	0.7	0.6	0.0	1.6	2.3	3.0
42, . . .	23	19	33	46	33	156	40	32	17	1.7	1.2	2.0	1.8	6.0	3.8	2.5
43, . . .	70	12	55	68	53	82	82	72	61	2.9	2.4	1.8	2.3	5.2	4.0	4.3
44, . . .	70	9	19	19	53	53	65	46	35	2.7	3.8	3.9	3.8	10.8	6.5	2.9
45, . . .	70	2	110	50	40	32	93	118	202	27.0	54.0	26.0	15.0	24.0	16.0	12.0
46, . . .	70	5	95	43	58	53	88	121	31	3.1	4.1	3.7	2.9	5.6	4.5	3.8
49, . . .	70	1	125	90	48	33	213	64	-	3.7	2.0	2.0	3.0	22.0	18.0	-
Tot's and Av's,	-	113	68	60	51	74	88	82	75	7.5	9.0	7.8	7.0	11.5	12.1	5.6

The average results from all of the filters indicate that there was a very slight decrease in bacterial efficiency, after scraping, by the method of operation practised. Taking the results individually it was found that out of 113 scrapings an increase in the number of bacteria in the effluents just after scraping, above that accounted for by the ordinary bacterial fluctuations, occurred in the case of the water bacteria 46 times and in the case of *B. prodigiosus* 55 times. Almost without exception the increase in number of bacteria was very slight, as will be seen in the table below, which contains the results obtained from each filter when the effect of scraping was most marked. In the second table beyond are given the results when the effect of scraping was the least marked in the case of each filter. During the period in which the results given in these tables were obtained the water bacteria in the applied water averaged 10,500 and the *B. prodigiosus* 7,000 per cubic centimeter.

Table showing the Number of Bacteria per Cubic Centimeter in the Effluent of Each Filter during Different Portions of the Period between Scrapings when the Effect of Scraping was Most Marked.

Number of Filter.	Water Bacteria.							Bacillus Prodigiosus.						
	Remaining Days.	Before Scraping.			After Scraping.			Remaining Days.	Before Scraping.			After Scraping.		
		Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.		Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.
33 A, .	51	82	43	27	45	118	-	1.8	0.0	0.0	0.0	1.0	3.0	-
34 A, .	14	7	6	-	108	19	23	3.0	2.0	2.0	-	3.0	1.0	3.0
35 A, .	12	12	2	3	16	14	-	0.4	0.0	0.0	0.0	5.0	3.0	-
36 A, .	117	76	114	227	329	168	-	0.8	1.0	0.3	1.0	1.0	2.0	-
38, . .	15	8	8	6	20	8	5	2.0	3.0	2.0	2.0	8.0	0.5	0.0
39, . .	11	-	9	9	36	16	36	7.0	-	9.0	4.0	9.0	21.0	9.0
41, . .	19	8	20	17	148	98	282	1.4	0.8	0.3	-	3.0	2.0	4.0
42, . .	7	-	12	5	63	24	16	0.0	-	0.0	1.0	18.0	15.0	13.0
43, . .	22	-	11	7	12	47	14	5.6	-	5.0	3.0	11.0	1.0	1.0
44, . .	19	-	11	4	35	109	39	3.0	-	11.0	3.0	9.0	3.0	2.0
45, . .	82	-	-	26	69	163	351	12.0	-	-	2.0	17.0	12.0	3.0
46, . .	43	-	-	80	172	395	26	3.0	-	-	1.0	10.0	7.0	4.0
Av's, .	34	-	-	37	88	98	-	3.3	-	-	2.1	7.5	6.3	-

Table showing the Number of Bacteria per Cubic Centimeter in the Effluent of Each Filter during Different Portions of the Period between Scrapings when the Effect of Scraping was Least Marked.

Number of Filter.	Water Bacteria.							Bacillus Prodigiosus.						
	Remaining Days.	Before Scraping.			After Scraping.			Remaining Days.	Before Scraping.			After Scraping.		
		Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.		Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.
33 A, .	9	10	-	16	17	6	8	1.0	3.0	-	0.2	0.2	0.0	0.8
34 A, .	8	8	4	8	7	7	10	0.2	0.2	4.0	4.0	0.5	2.0	1.0
35 A, .	40	-	11	18	6	60	36	5.6	-	0.0	0.0	0.0	0.0	0.0
36 A, .	64	-	5	2	5	2	5	2.0	-	0.0	0.0	0.0	0.0	0.3
38, . .	18	37	-	30	8	6	8	1.0	1.0	-	2.0	1.0	0.3	0.0
39, . .	45	11	49	42	17	16	-	3.0	10.0	4.0	2.0	4.0	3.0	-
41, . .	13	8	9	12	26	21	-	1.9	2.0	1.0	-	2.0	3.0	-
42, . .	16	9	9	12	10	10	4	1.6	0.0	0.0	2.0	0.8	1.0	0.2
43, . .	28	37	26	40	19	-	18	1.0	0.5	0.5	1.0	2.0	2.0	1.0
44, . .	27	10	-	-	6	3	4	0.5	0.0	-	-	0.0	1.0	2.0
45, . .	137	50	40	37	117	73	54	41.0	54.0	26.0	28.0	31.0	20.0	21.0
46, . .	38	15	-	30	43	17	23	3.1	0.3	-	1.5	3.0	4.0	7.0
Av., .	37	-	-	22	23	20	-	5.2	-	-	3.7	3.8	3.3	-

The Effect upon Bacterial Purification of disturbing the upper Twelve Inches of Filters of Fine Material.

Filters No. 33 A (continuous) and 41 (intermittent), containing 48 inches in depth of sand of an effective size of 0.14 millimeter, were scraped on July 17, after draining. This sand is so fine that the lower portion of the filter remains saturated after draining. The upper 12 inches of material were taken out and replaced. Water was applied at the top of the continuous filter, with the outlet closed, and after the surface was covered the faucet below was opened to give the usual rate of two million gallons per acre daily. The faucet of the intermittent filter was kept wide open and the rate of filtration regulated at the top.

In the following table are given the bacterial results from these filters for the week preceding and the week following this treatment. No *B. prodigiosus* was applied on July 17; the results on that day represent drainings. On all other days the results are averages of four examinations.

Bacteria per Cubic Centimeter.

Date — 1893.	Applied Water.		Effluent of Filter No. 33 A.		Effluent of Filter No. 41.	
	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
July 10,	2,100	8,000	12	0.3	11	2.0
11,	8,300	5,200	18	0.5	20	0.7
12,	6,100	6,000	102	0.3	75	8.0
13,	7,500	5,700	39	3.0	43	3.0
14,	4,400	4,300	40	2.0	18	1.0
15,	2,800	6,700	77	2.0	13	0.7
17,	1,000	0	47	0.0	28	0.0
18,	1,900	5,700	16	4.0	33	6.0
19,	7,700	5,200	24	3.0	46	4.0
20,	10,000	9,700	19	3.0	38	11.0
21,	5,900	6,300	23	2.0	58	11.0
22,	3,300	6,700	6	1.0	36	3.0

The Effect upon Bacterial Purification of Removing an Inch Layer of Loam Two Inches below the Surface of an Intermittent Filter of Medium Fine Sand.

Filter No. 35 A contained 48 inches in depth of sand of an effective size of 0.20 millimeter. After draining, on July 17 the surface was scraped, the loam layer 2 inches below the surface taken out and the sand replaced. The faucet below was kept wide open and the rate of the applied water regulated at the top. The bacterial results before and after this treatment were as follows: —

Bacteria per Cubic Centimeter.

Date — 1893.	Applied Water.		Effluent of Filter No. 35 A.	
	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
July 10,	2,100	8,000	9	1.0
11,	8,300	5,200	7	0.0
12,	6,100	6,000	17	0.3
13,	7,500	5,700	27	0.5
14,	4,400	4,800	64	0.0
15,	2,800	6,700	60	0.3
17,	1,000	0	50	0.0
18,	1,900	5,700	57	13.0
19,	7,700	5,200	164	7.0
20,	10,000	9,700	44	10.0
21,	5,900	6,300	81	13.0
22,	3,300	6,700	52	7.0

The results presented in the last two tables indicate that a slight decrease in bacterial efficiency follows a mechanical disturbance of the upper portion of fine filters and the removal of a layer of fine loam. From our general knowledge of the efficiency of coarser

filters it is probable that in such cases the diminution would be more marked. The effect of mechanical disturbance is brought out most clearly by the results obtained from Filters Nos. 3 B and 8 A.

These filters are one two-hundredth of an acre in area and contain five feet in depth of sand of an effective size of 0.23 millimeter. Filter No. 3 B has been operated intermittently at an average rate of two million gallons per acre daily since September 23, as follows: at 5 A.M. the gate on the outlet pipe is closed and the water turned on at the top near the edge. When the filter is covered (about 7.30 A.M.) the gate on the outlet pipe is opened to give the prescribed rate of filtration, and the surface is kept covered until 9 P.M. when the water is shut off and the filter allowed to drain during the night. No. 8 A has been operated continuously since September 26 at a constant rate of two million gallons per acre daily. While the passage of water through No. 8 A is uniform and causes no disturbance of the sand, the peculiar method of daily filling in No. 3 B drives out a large part of the air contained in the sand and causes more or less disturbance of the sand at the surface. That this disturbance of the surface is due to the escape of air from the sand can be readily seen from inspection, and is further indicated by the fact that up to January 1, No. 8 A was scraped three times to relieve clogging, while No. 3 B was not scraped at all during this period, although it yielded as much water. In the table below are given the average results of daily bacterial examinations of samples taken at different hours during the day from the effluent of each filter, from October 30 to December 8. The number of bacteria per cubic centimeter in the applied water averaged 8,800 during this period.

Bacteria per Cubic Centimeter.

Date. (October 30 to Dec. 8, 1898.)	Effluent of Filter No. 3 B. (Intermittent.)				Effluent of Filter No. 8 A. (Continuous.)			
Hour,	8 A.M.	11 A.M.	2 P.M.	4 P.M.	8 A.M.	11 A.M.	2 P.M.	4 P.M.
Bacteria in effluents,	320	286	185	140	104	119	126	103
Per cent. of number of applied bacteria which appeared in effluents,	3.63	3.25	2.10	1.59	1.18	1.35	1.48	1.17

The diminished efficiency of No. 3 B in the forenoon appears to be due to the mechanical disturbance of the main body of the sand by the escaping air.

The Effect upon Bacterial Purification of Freezing the Surface Layers of a Filter.

The freezing of the upper layers of a filter which has been drained also appears to aid in causing the passage of more bacteria through the filter. The weather during the second and third week in December was very cold and the surface of No. 3 B froze during the night after draining. The last week in the month was much warmer. Upon comparison of the results below with those presented above it will be seen that No. 3 B was less efficient than usual during the severe weather, but the results became normal again when warmer weather appeared.

Average Weekly Numbers of Bacteria per Cubic Centimeter.

Week Ending —	Effluent of Filter No. 3 B. (Intermittent.)				Effluent of Filter No. 3 A. (Continuous.)			
	8 A.M.	11 A.M.	2 P.M.	4 P.M.	8 A.M.	11 A.M.	2 P.M.	4 P.M.
1892.								
December 16,	259	236	310	273	40	51	50	78
23,	297	232	249	388	86	82	92	102
30,	285	263	159	147	74	65	68	86

Effect upon Bacterial Purification of Rapidly Filling Filters from Below after Draining.

During November several of the small filters, when their pores contained more or less air, were filled from below with filtered water. It is not known definitely how fast the water flowed into the filters, but in a majority of cases the rate was high, — probably equivalent to 5,000,000 gallons per acre daily or more.

More information is needed upon this point, but from the results given below it is clear that by rapidly filling a filter from below it is possible to disturb the sand so that the bacterial efficiency will be much diminished upon resuming filtration.

In the case of the several filters in question the numbers of bacteria in the effluents during the three days before and three days after filling from below are as follows: —

Average Daily Numbers of Bacteria per Cubic Centimeter.

Number of Filter.	Water Bacteria.						Bacillus Prodigiosus.					
	Before filling.			After filling.			Before filling.			After filling.		
	Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.	Third Day.	Second Day.	First Day.	First Day.	Second Day.	Third Day.
33 A, ...	18	13	21	72	20	17	0.0	0.0	0.0	3.0	2.0	0.6
38, ...	24	14	-	40	132	141	1.0	1.0	-	5.0	25.0	25.0
42, ...	9	8	-	109	45	42	0.3	0.3	-	24.0	21.0	16.0
43, ...	70	55	103	675	206	241	10.0	6.0	3.0	3.0	18.0	4.0
44, ...	39	31	70	209	321	256	2.0	4.0	3.0	9.0	34.0	12.0
46, ...	53	28	-	252	201	165	10.0	5.0	-	66.0	53.0	36.0
49, ...	26	-	46	176	69	91	5.0	-	13.0	69.0	16.0	25.0

In some instances only a very small portion of water, applied after the filter was put in operation after filling from below, appeared during that day as effluent. Under such circumstances the bacteria were lower than on the following day.

Some experiments have been made upon Filter No. 8 A, in which the filter, after scraping, was filled from below with city (filtered) water at a rate not exceeding 1,500,000 gallons per acre daily. The results thus far obtained indicate that no diminution in the bacterial efficiency follows this operation.

Conclusions.

From the evidence at hand it appears fair to conclude that —

1. No appreciable diminution in the bacterial efficiency of the experimental filters followed scraping, provided there was no mechanical disturbance of the main body of the sand.

2. Filters may be scraped without interfering with their bacterial efficiency by draining the water slightly below the surface of the sand and, after scraping, slowly filling from the top.

3. Filters may be drained and slowly filled from below, after scraping, without diminishing their bacterial efficiency.

4. When filters are drained and filled quickly from below, after scraping, there is an increase in the number of bacteria in the effluent.

5. When filters are drained and filled rapidly from the top a disturbance of the sand follows in the case of some of the experimental filters, which causes a diminution in the bacterial efficiency.

The Effect upon Bacterial Purification of the Amount of Loss of Head.

In some places abroad it is believed that the bacterial efficiency of a filter decreases as the loss of head increases beyond a certain limit. For this and other reasons several of the most recently constructed water filters in Germany are so arranged that the available head is very much less than the total depth of water and sand; in fact, in some instances the available head is less than 2.5 feet. The Lawrence results obtained in 1892 have been arranged to throw light upon this subject and are presented in the table below. In all cases these filters were scraped when the loss of head equalled the total depth of sand and water; and it was just before scraping, of course, that the loss of head approximated the maximum. The next table shows the average number of bacteria per cubic centimeter in the effluent during the three days before and the three days after scraping each filter, as well as the numbers during the intermediate days, that is, the remaining days of each period between scrapings. Owing to the growth of bacteria in some of the filters during mid-summer (see Annual Report for 1892, page 530) the results are divided into three periods, viz.: spring, summer and fall. It may also be stated that the numbers of bacteria in the effluents during each of the three days before scraping were substantially the same with the exception of a few instances in mid-summer when the bacterial growths occurred.

Summary of Results showing Uniformity of Bacterial Purification by Water Filters during Periods between Scrapings—1892.

Number of Filter.	Maximum Loss of Head. — Inches.	Spring (May 1 to July 15).			Summer (July 16 to August 31).			Fall (September 1 to November 1).			Number of Scrapings.
		Intermediate Days.	Three Days Before.	Three Days After.	Intermediate Days.	Three Days Before.	Three Days After.	Intermediate Days.	Three Days Before.	Three Days After.	
33 A, . .	70	44	65	68	67	649	2,418	55	43	47	7
34 A, . .	70	20	27	11	195	162	485	28	32	36	14
35 A, . .	70	34	23	24	22	2,656	25	99	45	86	6
36 A, . .	70	20	26	19	708	69	104	40	18	32	4
37, . .	70	11	27	64	95	4,664	180	44	86	65	5
38, . .	36	12	29	104	2,104	121	223	86	46	78	8
39, . .	23	68	74	115	89	7,455	864	45	54	67	16
40, . .	23	61	46	64	435	392	186	42	39	49	10
41, . .	70	26	3	115	71	70	60	29	37	32	7
Tot's and Av's, .	. .	42	36	65	415	1,793	504	52	37	57	77
Total Av.,	. .	47	36	61	(Spring and Fall.)			-	-	-	-

These results show that during the spring and fall there was no diminution in the bacterial efficiency of these experimental filters as the loss of head approached and reached the maximum (total depth of water and sand); neither was there any apparent difference in this regard between those filters which had a maximum loss of head of 70 inches and those in which the maximum loss was less than half of this amount. It will be seen that during midsummer the highest number of bacteria in the effluent in some cases did appear when the loss of head was greatest. This was undoubtedly due to the conditions existing in the filter which favored the continuance of life and growth of certain species of bacteria, and the high numbers occurred just before scraping and when the loss of head was greatest, because the accumulation of organic matter (food) was largest at that time.

The average results obtained from all of the small water filters in 1893 with regard to this point are presented in the table on page 463. These averages contain all results, including those of midsummer, when the abnormal growth of bacteria occurred within the filters. This growth, however, was much less marked than in 1892. The final averages for 1893 confirm the results obtained during the preceding year and show clearly that with these experimental filters, under the existing methods of operation, there is ordinarily no appreciable diminution in the bacterial efficiency caused by increases in loss of head up to 70 inches.

In the case of the continuous Filter No. 8 A (one two-hundredth of an acre in area) there were several occasions, notably December 1 and 29 (see beyond), when the number of bacteria increased in the effluent, just before scraping, and the loss of head reached the total depth of the filter. There was no trap on the outlet pipe of this filter, and the bacteria in the effluent did not increase until the loss of head had practically reached the maximum and when there was not enough pressure on the open gate to cause the prescribed quantity of effluent to pass. Under these circumstances air entered the filter through the outlet pipe, and the water probably filtered through the sand in certain places of least resistance at a relatively high rate. It is believed that these results are very exceptional and caused by the entrance of air from below through the untrapped outlet. It is of importance to note that the bacterial results were normal so long as there was any pressure upon the outlet gate in excess of that necessary for the passage of the prescribed quantity

of water. Furthermore, the outlet was kept trapped at later dates and no increase in the numbers of bacteria in the effluent was found just before scraping, although the scraping was deferred until the filter ran nearly dry.

It is also to be noted that in the case of the Lawrence city filter during January and February (see tables beyond) the number of bacteria in the effluent remained reasonably constant up to February 19, the date when scraping in sections began, although the loss of head increased from 3 to 7.6 feet.

The Effect upon the Bacterial Purification of the Method of Application of Water.

In comparing the efficiency of the intermittent with that of the continuous filters it is to be kept in mind that several different ways have been employed for allowing the entrance of air into the pores of the intermittent water filters. In most cases, up to October 1, 1893, the outlets of the intermittent filters have been untrapped and kept wide open, while the rate of filtration of water has been regulated at the inlet on the surface; these filters have been worked sixteen hours a day on six days in a week and allowed to drain the remainder of the time. Other filters, such as the older ones, No. 18 A and 20 A, also had the outlet untrapped and wide open, but received the contents of a small reservoir which was automatically discharged upon the surface at frequent and regular intervals, days, nights and Sundays. Beginning October 1, 1893, all of the intermittent filters have been operated as follows: at 5 A.M., after draining, the untrapped outlet has been closed and the water turned on at the top, which forces out the air at the surface. When the surface is covered and the air driven out of the pores of the sand (about 7.30 A.M.) the gate on the outlet pipe is opened to give the prescribed rate and the surface kept covered with water. At 9 P.M. the water is shut off at the top and the filter allowed to drain over night. In this method of operation there are two features which are not necessarily a part of intermittent filtration.

I. The actual rate of filtration during the hours the filter was operated was 50 per cent. higher than the average rate for twenty-four hours in order that the yield of effluent in sixteen hours should equal that of the continuous mate in twenty-four hours.

II. The exclusion of air from the pores of the sand by the manner of filling the filters and the resulting disturbance of the surface by the escaping air.

In studying the results obtained from the several pairs of intermittent and continuous filters, which are presented below, the different methods of operation of the intermittent filters are not to be forgotten, and are as follows: up to October 1 and from November 21 to 30 the intermittent filters, Nos. 41, 45, 47 and 48, were operated sixteen hours a day on six days in a week, with the outlet untrapped and wide open and the rate of filtration regulated at the inlet at the surface. During the rest of the period covered by these results the untrapped outlet was closed after draining and water applied at the top; when the surface was covered the outlet was opened to give the prescribed rate.

Table showing a Comparison of the Number of Bacteria, per Cubic Centimeter, arranged as Weekly Averages, in the Effluents of each Pair of Continuous and Intermittent Filters.

Number of Filter.	33A.		41.		43.		45.		44.		47.		49.		48.	
	Continuous.		Intermittent.		Continuous.		Intermittent.		Continuous.		Intermittent.		Continuous.		Intermittent.	
Week ending — 1893.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
May 13, .	10	1.5	44	-	-	-	-	-	-	-	-	-	-	-	-	-
20, .	10	0.8	10	0.5	(Ne	w.)	-	-	(Ne	w.)	-	-	-	-	-	-
27, .	7	5.3	7	2.7	1,339	67.0	-	-	391	74.0	-	-	-	-	-	-
June 3, .	10	1.3	10	1.2	541	20.0	-	-	172	24.0	-	-	-	-	-	-
10, .	10	0.8	11	2.1	287	3.8	-	-	118	8.0	-	-	-	-	-	-
17, .	12	0.6	6	0.2	292	-	-	-	51	-	-	-	-	-	-	-
24, .	6	0.1	11	2.5	226	-	-	-	50	-	-	-	-	-	-	-
July 1, .	29	0.8	12	1.8	292	-	-	-	46	-	-	-	-	-	-	-
8, .	15	4.2	17	1.8	140	5.2	(Ne	w.)	23	3.8	-	-	-	-	-	-
15, .	48	1.4	30	1.7	63	4.0	1,586	92.0	44	6.0	-	-	-	-	-	-
22, .	23	2.6	40	7.0	38	8.4	279	140.0	30	13.0	-	-	-	-	-	-
29, .	306	2.2	47	7.0	58	5.2	177	52.0	19	7.5	-	-	-	-	-	-
Aug. 5, .	54	4.7	49	12.3	33	11.2	155	52.0	25	11.5	-	-	-	-	-	-
12, .	90	1.7	30	4.3	29	5.0	81	19.0	19	2.4	-	-	-	-	-	-
19, .	51	1.7	32	7.2	23	6.0	62	30.0	40	11.0	-	-	-	-	-	-
26, .	149	2.7	15	2.7	18	8.6	107	21.0	40	4.8	-	-	-	-	-	-
Sept. 2, .	190	0.3	68	0.6	19	0.4	66	3.0	22	0.3	-	-	-	-	-	-
9, .	26	1.5	26	1.3	10	0.6	185	7.6	4	0.5	(Ne	w.)	(Ne	w.)	(Ne	w.)
16, .	30	3.7	17	1.6	11	2.4	153	9.5	9	1.0	1,630	371.0	647	46.	1,912	244.2
23, .	20	1.0	51	9.0	15	1.3	129	6.8	8	0.8	1,283	78.3	236	1.8	1,151	99.5
30, .	120	1.4	96	1.9	171	4.5	2,143	16.2	169	2.5	3,671	55.0	111	4.7	6,547	51.5
Oct. 7, .	64	0.8	34	1.1	45	1.3	1,186	23.5	22	0.3	1,436	18.5	186	3.3	848	62.0
14, .	46	0.1	20	0.4	30	0.9	188	8.2	15	0.5	607	24.0	87	3.0	885	42.0
21, .	24	0.0	11	0.2	24	0.6	114	9.0	14	0.5	274	15.0	87	9.0	320	25.0
28, .	26	0.1	14	0.5	94	26.0	56	8.0	37	6.5	71	13.0	85	11.0	81	14.0
Nov. 4, .	17	0.0	10	0.5	35	13.0	68	11.0	27	10.0	62	24.0	56	18.0	83	27.0
11, .	20	0.6	11	0.5	71	9.0	107	12.0	57	5.0	180	25.0	93	9.0	182	28.0
18, .	16	0.6	12	0.8	45	12.0	38	7.5	42	7.0	154	30.5	86	26.0	133	33.0
25, .	27	0.9	7	0.0	225	7.0	105	14.0	154	11.0	541	47.0	89	3.2	93	16.0
Dec. 2, .	64	2.4	10	0.0	234	18.4	286	18.0	201	14.0	276	25.0	87	6.0	128	10.0

The results obtained from Filters Nos. 3 B and 8 A are instructive in this connection; the summarized and detailed results are given in tables which may be found beyond.

The results at hand, obtained from the several pairs of continuous and intermittent filters, show —

1. That in the case of the filters of very fine sand (in which there is a saturated layer of considerable depth) the bacterial efficiency was substantially the same by each method employed in the application of water during the greater part of the period, but during midsummer (July 24 to September 2) the continuous filter allowed a few more of the hardy water bacteria, but not of *B. prodigiosus*, to pass through.

2. That with filters of coarser sands, operated at comparatively high rates, the continuous filters were ordinarily more efficient in removing bacteria than the intermittent filters under the existing methods of operation. The reason of this is that the actual rate of flow was lower and more uniform and there was no mechanical disturbance of the sand as was the case during the greater part of the period with the intermittent filters, owing to the manner of filling and driving out the air at the surface.

Chemical Purification of Water by Filtration.

The results of the chemical analyses, from May to November, inclusive, indicate that on an average 45 per cent. of the total albuminoid ammonia, of which 15 to 20 per cent. is usually in suspension, in the applied river water appeared in the effluents. The total albuminoid ammonia of the river water which appears in the effluents ordinarily ranges from 35 to 60 per cent.; the extremes are 30 and 70 per cent.

A comparison of the efficiency with regard to the removal of organic matter of filtration under different conditions is presented below. For details regarding methods of operation and results of analyses see pages beginning with 488.

Table showing Per Cent. of Albuminoid Ammonia in Applied Water which appeared in the several Effluents at Different Rates of Filtration.

[Rates are expressed in million gallons per acre daily.]

Number of Filter.	Method of Operation.	Effective Size of Sand Grain. — Millimeter.	May.		June.		July.		Aug.		Sept.		Oct.		Nov.	
			Rate.	Albuminoid Ammonia.	Rate.	Albuminoid Ammonia.	Rate.	Albuminoid Ammonia.	Rate.	Albuminoid Ammonia.	Rate.	Albuminoid Ammonia.	Rate.	Albuminoid Ammonia.	Rate.	Albuminoid Ammonia.
18 A, .	Intermittent.	.48	1.5	55.	2.3	42.	1.7	42.	1.9	36.	1.7	57.	1.6	57.	1.8	53.
33 A, .	Continuous.	.14	1.7	48.	1.7	39.	1.9	37.	2.7	37.	1.9	46.	1.9	42.	2.8	46.
34 A, .	Continuous.	.09	1.6	47.	1.4	47.	1.9	40.	2.8	35.	-	-	-	-	-	-
35 A,	Intermittent. Continuous.	.20	1.4	49.	1.2	39.	1.7	37.	3.0	34.	-	-	-	-	-	-
36 A,	Continuous. Intermittent.	.20	2.0	51.	2.0	40.	3.0	37.	1.7	35.	1.2	43.	-	-	-	-
37, .	Continuous.	.20	1.7	47.	3.4	44.	-	-	-	-	-	-	-	-	-	-
38, .	Continuous.	.20	1.9	53.	1.7	40.	1.9	37.	2.5	40.	1.9	39.	2.0	48.	3.4	53.
39,	Continuous. Intermittent.	.20	2.0	53.	1.6	41.	1.5	55.	1.7	46.	-	-	-	-	-	-
41, .	Intermittent.	.14	2.0	48.	1.5	47.	2.0	41.	1.9	37.	1.9	51.	1.8	41.	1.6	49.
42, .	Continuous.	.20	1.9	51.	1.7	43.	1.9	40.	1.9	32.	1.8	47.	2.0	50.	1.9	47.
43, .	Continuous.	.26	2.2	55.	3.9	49.	2.8	43.	4.3	37.	4.5	55.	4.8	47.	7.6	51.
44, .	Continuous.	.29	2.2	60.	2.8	48.	2.8	42.	4.3	37.	4.7	57.	5.8	46.	7.6	52.
45, .	Intermittent.	.23	-	-	-	-	1.5	51.	1.9	40.	1.7	72.	1.8	48.	3.6	52.
46, .	Continuous.	.29	-	-	-	-	-	-	-	-	1.9	63.	2.3	44.	3.6	54.
47, .	Intermittent.	.29	-	-	-	-	-	-	-	-	1.7	70.	1.8	56.	3.6	59.
48, .	Intermittent.	.38	-	-	-	-	-	-	-	-	1.8	67.	1.8	55.	2.9	57.
49, .	Continuous.	.38	-	-	-	-	-	-	-	-	2.1	69.	2.6	42.	5.3	57.

In filters of these materials, and in which nitrification is well established, the rate of filtration, within these limits, appears to exert very little or no influence upon the removal of organic matter.

Effect of Size of Sand Grain.

The results obtained in October and November were selected for the following table because they were obtained under comparable conditions.

I. Continuous Filters.

Number of Filter.	Effective Size of Sand Grain. — Millimeter.	Average Rate of Filtration. — Million Gallons per Acre Daily.	Per Cent. of Albuminoid Ammonia in Applied Water which Appeared in Effluents.	Per Cent. which Oxygen Consumed in Effluents was of that in Applied Water.
33 A,	.14	2.4	44.	76.
38,	.20	2.7	50.	82.
43,	.26	6.2	49.	78.
44,	.29	6.7	50.	80.
49,	.38	4.0	49.	78.

II. Intermittent Filters.

41,	.14	1.7	45.	78.
45,	.23	2.7	50.	76.
47,	.29	2.7	57.	80.
48,	.38	2.4	56.	80.
18 A,	.48	1.7	55.	91.

In continuous and intermittent filtration, through materials of these limits in effective size and under the given conditions of operation, there was no marked difference in the amounts of organic matter removed from the applied water by the filters which were filled with sand of different effective sizes.

Effect of Depth of Material.

Number of Filter.	Effective Size of Sand Grain. — Millimeter.	Depth in Inches.	Average Rate of Filtration. — Million Gallons per Acre Daily.	Period. 1893.	Per Cent. of Albuminoid Ammonia in Applied Water which Appeared in Effluents.	Per Cent. which Oxygen Consumed in Effluents was of that in Applied Water.
37,	.20	55	2.6	May and June.	45.	81.
38,	.20	20	1.8	May and June.	46.	81.
39,	.20	1	1.8	May and June.	47.	78.
42,	.20	10	1.8	May and June.	47.	86.
44,	.29	60	2.6	May and June.	54.	74.
46,	.29	12	2.9	Oct. and Nov.	49.	80.
44,	.29	60	6.7	Oct. and Nov.	49.	80.

There was practically no difference in the power of removal of organic matter from the river water by the several filters of each series. It is to be remembered that in addition to the sand each filter contained 5 inches of underdrains.

In 1892 the results obtained from the first series of filters indicated that the deeper were somewhat more effective than the shallower filters. It is believed that the 1893 data are fairer because they were obtained under strictly comparable conditions.

Effect of the Method of Application of Water.

In the Annual Report of the Board for 1892 (page 466) it was shown that there was practically the same amount of free and albuminoid ammonia in the effluents of the continuous and the intermittent filters. The nitrates, however, were higher in the effluents of the latter.

It is to be again stated that it is necessary to consider the different methods practised in running the intermittent filters, and the peculiar features of each. In this connection see page 472.

Nearly all of the samples of effluents of intermittent filters analyzed during 1892 were collected within two or three hours of the time when the effluent began to flow after the interval of rest. The results of the analyses of more extended series of samples collected during different hours of the day in 1893 show that such samples in a majority of cases are not representative with respect to the nitrates in the case of the effluents of intermittent filters under the existing method of operation. The variations are shown by the representative analysis given below of samples from No. 41, taken on September 20. This filter was operated sixteen hours a day with the faucet below always open and untrapped, the rate regulated at the top and the filter allowed to drain during the remaining hours.

[Parts per 100,000.]

Effluent of Filter Number	Hour.	Gallons passed since Interval of Rest.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
				Free.	Albuminoid.		Nitrates.	Nitrites.	
41,	8.52 A.M.	1	.18	.0010	.0064	.22	.0290	.0000	.21
41,	9.12 A.M.	3	.18	.0012	.0076	.22	.0330	.0000	.21
41,	11.20 P.M.	22	.19	.0014	.0092	.22	.0310	.0000	.22
41,	1.30 P.M.	40	.20	.0020	.0106	.22	.0290	.0000	.22
41,	3.06 P.M.	52	.20	.0022	.0100	.22	.0240	.0000	.22
41,	5.06 P.M.	70	.20	.0022	.0092	.22	.0280	.0000	.23
33 A,	9.14 A.M.	-	.22	.0018	.0090	.22	.0280	.0000	.24
Applied water,	10.25 A.M.	-	.35	.0054	.0168	.22	.0150	.0000	.42

While it is seen that there is a marked variation during the day in the nitrates of the effluent of this intermittent filter under these conditions of operation there is, under ordinary circumstances, substantially no change in the effluent of continuous filters. This is

shown by the following table in which are given the average results of three sets of samples collected at 9 A.M. and 3 P.M. from the effluent of No. 33 A the mate of No. 41.

[Parts per 100,000.]

Hour.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
9 A.M.,	.27	.0017	.0110	.20	.0250	.0000	.29
3 P.M.,	.28	.0019	.0110	.20	.0250	.0000	.31

In the table below are given the average results obtained in October and November from the effluent of four pairs of continuous and intermittent filters. The intermittent filters were operated sixteen hours daily, six days in a week, with the outlets untrapped and closed while the filters, after draining, were filled with water from the top. After the air was driven from the pores and the surface covered the outlet gate was opened to give the prescribed rate of flow. Samples were collected at different hours during the day from the effluent of the intermittent filters, and it is believed that the results below, which correspond to the results of the analyses of samples collected four to six hours after the period of rest, are representative for the period.

Continuous Filters.

Number of Filter.	Effective Size of Sand Grain. — Millimeter.	Average Rate of Filtration. — Million Gallons per Acre Daily.	Per Cent. of Albuminoid Ammonia in Applied Water which appeared in Effluent.	Per Cent. of Oxygen Consumed in Applied Water which Appeared in Effluent.	Nitrogen as Nitrates. — (Parts per 100,000.)
33 A,	.14	2.4	44.	76.	.0240
43,	.26	6.2	49.	78.	.0240
44,	.29	6.7	49.	80.	.0240
49,	.38	4.0	49.	78.	.0220

Intermittent Filters.

41,	.14	1.7	45.	78.	.0250
45,	.23	2.7	50.	76.	.0220
47,	.29	2.7	50.	76.	.0200
48,	.38	2.4	57.	80.	.0220

These results indicate that during these months there was practically no difference in the average chemical purification effected by the continuous and intermittent filters under existing conditions of operation. The most substantial confirmation of this is that Filters Nos. 33 A and 41, a pair which had been operated over a year and a half, contained substantially the same amount of organic nitrogen in the sand on December 8, at the end of the period covered by the analyses presented above. The amount of organic matter in the sand removed by scraping was also the same (see tables, pages 484–486).

During the period of rest (8 hours) in the intermittent filters for the greater part of the year there was increased nitrification of the organic matter stored in the sand; when water was again applied the nitrates formed during the period of rest were gradually washed out, giving a higher quantity for several hours than is found in the effluents of continuous filters. After a time, depending upon the rate of flow, these high nitrates fall to the normal. The reason that the continuous filtration of water is successful, while with sewage this method is a failure, is that the applied water contains dissolved oxygen and, as will be seen from the table (page 482), the dissolved oxygen in the effluents of the continuous filters has never been found wanting. It is to be remembered in this connection that it was shown in the Special Report upon Purification of Sewage and Water, 1890, page 730, that a small amount of oxygen (1 to 3 per cent.) in the air of the filter was effective, provided the air was changed so often that some oxygen was always present at every point.

The results presented above are for the fall months, and it is believed that they are representative for the spring months also. But the evidence at hand indicates that the results are different in the warmest summer weather and in the severest winter weather.

In mid-summer the conditions for nitrification appear to be the most favorable both in continuous and intermittent filters but it is more marked in the case of the latter. This is brought out by the following table of monthly averages of effluents of Filters Nos. 33 A and 41 and by a series of analyses of the effluents. It will be noted that high nitrates in the effluent of the intermittent filter (outlet untrapped and kept wide open) were found when the quantity of effluent yielded after the period of rest exceeded the quantity of water held in the pores of the sand. In the case of the continuous as well as of the intermittent filter the effluent contained at times

more nitrogen than the applied water, showing a removal of organic matter stored in the sand. In most instances the samples from No. 41 were collected at 2 P.M. when series of samples were not taken.

Monthly Averages of Chemical Analyses.

[Parts per 100,000.]

June, 1893.

	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
Effluent of Filter No. 33 A,	.28	.0011	.0087	.15	.0335	.0000	.29
Effluent of Filter No. 41, .	.30	.0014	.0104	.16	.0255	.0000	.30
Applied water, . . .	.37	.0076	.0222	.17	.0180	.0000	.40

July, 1893.

	Color.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
Effluent of Filter No. 33 A,	.22	.0015	.0096	.19	.0347	.0000	.21
Effluent of Filter No. 41, .	.21	.0027	.0105	.20	.0407	.0000	.22
Applied water, . . .	.36	.0100	.0259	.19	.0200	.0002	.34

August, 1893.

	Color.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
Effluent of Filter No. 33 A,	.17	.0023	.0098	.20	.0297	.0013	.16
Effluent of Filter No. 41, .	.17	.0018	.0097	.20	.0364	.0000	.16
Applied water, . . .	.29	.0103	.0263	.20	.0180	.0001	.28

Results of a Series of Chemical Analyses on August 22, 1893.

[Parts per 100,000.]

	Hour.	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
			Free.	Albuminoid.		Nitrates.	Nitrites.	
Effluent of Filter No. 41 (intermittent).	9.50 A.M.	.18	.0032	.0068	.21	.0490	.0008	.13
	1.25 P.M.	.19	.0032	.0116	.21	.0530	.0000	.15
	3.12 P.M.	.19	.0014	.0066	.21	.0520	.0000	.14
Effluent of Filter No. 33 A (continuous).	10.20 A.M.	.19	.0016	.0106	.21	.0330	.0000	.15
	2.17 P.M.	.19	.0012	.0118	.21	.0290	.0014	.17
Applied water, ...	2.05 P.M.	.28	.0070	.0260	.21	.0190	.0004	.29

The above results obtained in the warmest weather indicate with regard to nitrification that, under the existing conditions of operation, the advantage lies with the intermittent filters. During the

winter months, with another pair of filters, Nos. 3 B and 8 A, the advantage lay with the continuous filter, as shown by the following table of monthly averages. No. 3 B was operated intermittently, — drained 8 hours daily, outlet untrapped and closed while filling; No. 8 A, continuously. The analyses were made of mixed samples collected in portions at different hours during the day and are believed to be representative.

Monthly Averages of Chemical Analyses.

[Parts per 100,000.]

	Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.
		Free.	Albuminoid.		Nitrates.	Nitrites.	
December, 1893.							
Effluent of Filter No. 3 B,	.38	.0029	.0121	.20	.0190	.0000	.42
Effluent of Filter No. 8 A,	.37	.0021	.0117	.20	.0220	.0000	.39
Applied water, . . .	.44	.0057	.0177	.20	.0150	.0000	.49
January, 1894.							
Effluent of Filter No. 3 B,	.38	.0021	.0117	.21	.0260	.0000	.36
Effluent of Filter No. 8 A,	.37	.0016	.0115	.21	.0300	.0000	.35
Applied water, . . .	.43	.0055	.0164	.21	.0150	.0001	.41
February, 1894.							
Effluent of Filter No. 3 B,	.34	.0018	.0107	.22	.0270	.0000	.36
Effluent of Filter No. 8 A,	.32	.0017	.0106	.22	.0310	.0000	.33
Applied water, . . .	.40	.0068	.0160	.23	.0180	.0001	.42
March, 1894.							
Effluent of Filter No. 3 B,	.40	.0014	.0095	.15	.0180	.0000	.35
Effluent of Filter No. 8 A,	.39	.0016	.0102	.15	.0180	.0000	.34
Applied water, . . .	.47	.0040	.0193	.15	.0180	.0001	.46

The differences in nitrification were most marked in January and February and disappeared in March. The reason of this is not yet fully understood, but it is possible that the daily exposure of the surface of No. 3 B where most of the organic matter is stored, to the cold atmosphere and the occasional formation of frost, may have interfered with the bacterial activity necessary for nitrification. It is

significant that series of samples taken at frequent intervals during the day from the effluent of No. 3 B showed no marked variations in amount of nitrates during the cold weather, but in April the series were similar to those obtained from No. 41 on September 20, 1893, and which were presented on page 477.

While considerable light has been obtained upon this subject it is still necessary to have additional data before we can draw final conclusions as to the relative merits of the two methods as well as to the best way of operating a filter intermittently.

Dissolved Oxygen in the Effluents.

In the table below is given the average amount of dissolved oxygen in the applied river water and in the effluents of the several filters. In no case was an absence of oxygen noted in the effluents of continuous filters. The effluents of the intermittent filters contained much more oxygen than did the effluents of continuous filters, and during midsummer the amount was in excess of that in the applied water. The analyses were made about four hours after the expiration of the period of rest in the intermittent filters, and it is probable that the quantity became less as the filter continued in operation.

Per Cent. which the Oxygen dissolved in the Applied Water and Effluents was of that necessary for Saturation at actual Temperatures.

Date — 1893.	In Applied Water.	In Effluents from Filters Number —																
		18 A	33 A.	34 A.	35 A.	36 A.	37.	38.	39.	41.	42.	43.	44.	45.	46.	47.	48.	49.
January, .	93.	98.	79.	73.	96.	69.	70.	79.	79.	99.	85.	-	-	-	-	-	-	-
February, .	96.	98.	71.	74.	74.	65.	72.	78.	86.	99.	80.	-	-	-	-	-	-	-
March, .	91.	98.	69.	80.	100.	66.	75.	82.	84.	100.	85.	-	-	-	-	-	-	-
April, . .	100.	100.	76.	75.	94.	86.	69.	78.	85.	95.	85.	-	-	-	-	-	-	-
May, . .	86.	97.	55.	65.	91.	71.	56.	68.	50.	89.	74.	100.	98.	-	-	-	-	-
June, . .	75.	91.	38.	54.	84.	64.	62.	43.	38.	51.	68.	74.	75.	-	-	-	-	-
July, . .	52.	93.	8.	22.	89.	15.	-	21.	62.	91.	11.	29.	38.	97.	-	-	-	-
August, .	69.	92.	12.	18.	50.	86.	-	27.	55.	79.	42.	33.	59.	95.	55.	-	-	-
September, .	81.	89.	31.	38.	-	-	-	60.	-	86.	56.	49.	46.	93.	49.	99.	99.	69.
October, .	86.	96.	54.	-	-	-	-	47.	-	94.	54.	60.	71.	98.	57.	99.	100.	61.
November, .	95.	100.	81.	-	-	-	-	83.	-	93.	81.	81.	80.	97.	81.	97.	98.	88.
December, .	98.	100.	87.	-	-	-	-	82.	-	96.	82.	86.	83.	98.	85.	95.	100.	89.

THE REMOVAL OF COLOR FROM WATER BY FILTRATION.

The per cent. of color of the applied water which appeared in the effluents of those filters started in 1892 was shown in the Annual Report for that year to be 55, on an average, after there had been filtered 400,000,000 gallons of water per acre. In 1893, after 800,000,000 gallons per acre had been filtered, the average amount of color in the effluents was 65 per cent. of that in the applied water.

The filter two feet deep (No. 38) was as efficient as those five feet deep.

The filters constructed in 1893 contained sand from Gale's Hill, a different source from that used for the earlier filters. This sand was also used for the Lawrence city filter. While in the earlier filters it was found that the sand was most effective in removing color when new, the sand from Gale's Hill removed practically none at first but gradually acquired this power, although apparently to a somewhat less extent than was possessed by the sand used in 1892 for filling filters.

The mineral analyses of the two sands are as follows: —

No. 38 (1892) sand contained 98.70 per cent. of material insoluble in strong sulphuric acid kept at the boiling temperature for two hours; 0.75 per cent. of alumina; 0.30 per cent. oxide of iron and 0.02 per cent. oxide of manganese.

Gale's Hill (1893) sand contained 97.70 per cent. of material insoluble in strong sulphuric acid kept at the boiling temperature for two hours; 0.96 per cent. of alumina; 0.54 per cent. oxide of iron and 0.13 per cent. oxide of manganese.

Number of Bacteria and Amount of Nitrogen found in the Sand of the Several Water Filters, December 8, 1893.

On this date, after the filters had drained twenty-four hours, numerous samples of sand at different depths were taken from each filter and analyzed chemically and bacterially, with results as follows: —

Number of Filter.	Depth. (Inches.)	Method of Operation.	Length of Time in Operation.	Million Gallons per Acre Filtered to Date.	Average Number of Bacteria in Sand per Gram.	Original Nitrogen in Sand. (Parts per 100,000.)	Average Increase of Nitrogen in Sand.* (Parts per 100,000.)
18 A, .	60	Intermittent.	4 years, 2 months.	1,687	78,000	1.0	2.90
33 A, .	60	Continuous.	1 year, 7 months.	1,138	82,200	0.8	1.24
38, .	24	Continuous.	1 year, 7 months.	1,092	213,500	1.3	2.97
41, .	60	Intermittent.	1 year, 7 months.	948	87,000	0.8	1.36
42, .	12	Continuous.	1 year, 1 month.	731	120,400	1.3	3.78
43, .	60	Continuous.	7 months.	907	136,600	0.8	1.12
44, .	60	Continuous.	7 months.	923	201,500	0.8	1.47
45, .	60	Intermittent.	5 months.	349	62,600	0.8	1.26
46, .	12	Continuous.	4 months.	287	201,600	0.8	2.53
47, .	60	Intermittent.	3 months.	241	93,500	0.8	1.20
48, .	60	Intermittent.	3 months.	201	98,500	0.8	0.46
49, .	60	Continuous.	3 months.	323	51,500	0.8	1.34

* The organic nitrogen was calculated as $\frac{1}{1}\frac{4}{7}$ of the albuminoid ammonia doubled.

Upon dividing the deep filters into two classes, according to the method of application of water, and summarizing the data, it is found that the intermittent filters contained 108 bacteria per gram and an increase in nitrogen of .0021 part per 100,000 for each million gallons of water filtered per acre; while for the continuous filters these figures become 122 and .0016, respectively. It is probable that somewhat different results would be obtained in mid-summer.

In the next tables the results of the analyses of the sand from the several filters are presented with greater detail. It is to be stated that the method followed until September, 1893, of scraping the filters and not replacing the sand removed, until the depth was decreased 6 to 12 inches, caused greater irregularities than would have been the case if the sand removed had always been replaced with clean material at the time of scraping.

Number of Bacteria per Gram found in the Sand at Different Depths, Dec. 8, 1893.

NUMBER OF FILTER.	18 A.	33 A.	38.	41.	42.	43.
Date when last scraped, .	Oct. 9.	Nov. 23.	Dec. 4.	Dec. 7.	Dec. 2.	Dec. 7.
Upper quarter-inch, . .	1,570,000	767,000	3,430,000	1,750,000	1,750,000	9,300,000
Upper inch, . . .	1,250,000	536,000	2,675,500	1,046,300	1,047,500	5,238,100
Upper six inches, . .	430,000	162,900	731,100	231,100	223,600	1,007,000
Upper foot, ...	267,000	103,000	369,300	141,600	120,400	576,900
Second foot, . . .	73,000	19,300	57,800	22,500	-	55,700
Third foot, ...	27,000	11,500	-	13,500	-	10,300
Fourth foot, . . .	13,000	11,500	-	3,700	-	18,100
Fifth foot, ...	10,600	-	-	-	-	22,200

Number of Bacteria per Gram found in the Sand at Different Depths, Dec. 8, 1893 — Concluded.

NUMBER OF FILTER.	44.	45.	46.	47.	48.	49.
Date when last scraped, .	Dec. 7.	Dec. 2.	Dec. 2.	Dec. 2.	Dec. 2.	Dec. 7.
Upper quarter-inch, . .	2,020,000	1,800,000	1,900,000	3,500,600	1,700,000	830,000
Upper inch, . . .	2,082,800	1,071,400	1,375,000	2,072,800	1,172,800	523,500
Upper six inches, . .	1,193,200	-	393,200	439,000	415,000	190,800
Upper foot, ...	621,900	153,300	201,600	265,500	336,700	131,700
Second foot, . . .	131,500	56,200	-	55,800	23,000	31,500
Third foot, ...	131,500	45,400	-	49,800	18,000	34,500
Fourth foot, . . .	110,600	22,200	-	48,800	20,000	30,000
Fifth foot, ...	12,100	31,100	-	46,800	-	-

Amount of Nitrogen stored in the Sand at Different Depths, Dec. 8, 1893.*

[Parts per 100,000 by weight of dry sand.]

NUMBER OF FILTER.	18 A.	33 A.	38.	41.	42.	43.	44.	45.	46.	47.	48.	49.
Upper quarter-inch, .	17.40	4.70	10.90	0.50	3.40	-	1.32	5.71	3.57	9.02	4.70	0.90
Upper inch, . . .	11.65	4.91	8.60	1.05	7.15	0.55	5.45	3.61	2.65	7.56	4.23	1.58
Upper six inches, .	5.21	2.03	5.98	0.39	4.45	3.19	5.91	1.60	1.32	5.42	2.41	5.09
Upper foot, . . .	6.30	0.72	4.14	0.05	3.78	3.47	4.32	2.47	2.53	3.77	0.68	4.42
Second foot, . .	5.10	4.40	1.30	4.30	-	1.00	1.37	2.05	-	0.94	0.60	0.90
Third foot, . . .	1.40	0.60	-	0.65	-	0.40	0.53	1.10	-	0.54	0.30	0.47
Fourth foot, . . .	0.30	0.25	-	0.90	-	0.30	0.58	0.36	-	0.40	0.35	0.45
Fifth foot, . . .	0.91	-	-	-	-	0.46	0.57	0.33	-	0.33	-	-

* Nitrogen in original sand deducted.

Considerable attention was given to the species of bacteria found in the sand at different depths in Filters Nos. 33 A, 41, 44 and 47. No very marked characteristics with respect to the distribution of the species of bacteria could be found in the samples of sand from the different sources. The presence of about fifteen species was noted.

In the following table are given the results of chemical and bacteriological analyses of representative samples of the clogged sand removed from the surfaces of the filters by scraping.

The number of bacteria per gram in these samples was found to be somewhat less than in samples just below the surface, as will be seen from the tables above. The reason of this appears to arise from the difficulty with which the bacteria are detached from the grains which are so thickly coated with the accumulation of gelatinous organic matter. From this it will be understood that the merit of determinations of bacteria in sand lies in their value for comparison and not as absolute determinations.

Number of Filter.	Average Number of Bacteria in Sand per Gram.	Number of Analyses made.	Average Quantity of Nitrogen in Sand. (Parts per 100,000 by Weight of Dry Sand.)	Number of Analyses made.
33 A,	820,000	4	23.9	4
34 A,	830,000	10	32.6	9
35 A,	650,000	4	26.6	3
36 A,	900,000	7	32.2	6
38,	1,500,000	6	30.5	6
39,	580,000	8	25.3	7
41,	540,000	5	23.3	5
42,	900,000	6	23.8	8
43,	910,000	7	42.3	8
44,	[illegible]	5	22.1	6
45,	540,000	2	17.4	2
Totals and averages,	800,000	64	27.3	64

THE RELATION BETWEEN CONSTRUCTION AND OPERATION OF FILTERS AND THE QUANTITY OF SAND SCRAPED FROM THE SURFACES TO RELIEVE CLOGGING.

The data obtained in 1893 upon this point are summarized in the table below. These results cover the period May to November, inclusive. As far as can be judged from the analyses of the applied water, it is believed that they are representative for the entire year. The increased viscosity of the water during the winter months, other conditions being equal, would probably reduce somewhat the quantities of water filtered between scrapings.

The depths of sand removed were calculated in each case from the weight of the sand. It will be seen that in the case of those experimental filters having a maximum loss of head of 70 inches the volume of sand removed, per million gallons of water filtered, was in many cases approximately the same.

Summary of Results of Scraping of Water Filters, May to November, 1893.

Number of Filter.	Effective Size of Sand Grain. — Millimeters.	Approximate Depth of Sand. — Inches.	Maximum Loss of Head. — Inches.	Method of Operation.	Number of Scrapings.	Average Depth Removed at each Scraping. — Inches.	Average Quantity of Water Filtered per Acre between Scrapings. — Gallons.	Volume of Sand Removed per Million Gallons. — Cubic Yards.
33 A, . .	.14	60	70	Continuous.	8	.23	49,000,000	.63
34 A, . .	.09	45	70	Continuous.	17	.12	14,000,000	1.16
35 A,* .	.20	48	70	Intermittent.	8	.25	92,000,000	.36
36 A,* .	.20	48	70	Continuous.	7	.21	35,000,000	.82
37,* . .	.20	55	70	Continuous.	1	.20	141,000,000	.19
38, . .	.20	20	35	Continuous.	18	.17	22,000,000	1.06
39,* . .	.20	1	23	Continuous.	14	.15	13,000,000	1.55
41, . .	.14	60	70	Intermittent.	8	.19	56,000,000	.46
42, . .	.20	10	23	Continuous.	24	.16	19,000,000	1.11
43, . .	.26	60	70	Continuous.	16	.26	57,000,000	.63
44, . .	.29	60	70	Continuous.	13	.30	70,000,000	.58
45, . .	.23	60	70	Intermittent.	4	.28	78,000,000	.48
46, . .	.29	12	23	Continuous.	9	.25	29,000,000	1.16
47, . .	.29	60	70	Intermittent.	2	.45	100,000,000	.60
48, . .	.38	60	70	Intermittent.	1	.88	181,000,000	.66
49, . .	.38	60	70	Continuous.	4	.32	79,000,000	.58

* Nos. 35 A and 36 A were complicated by loam layers. No. 37 was scraped but once, and during a portion of the period channels were formed at the sides. For a short time Nos. 36 A and 39 were run intermittently, while No. 35 A was operated continuously for a brief period.

Conclusions.

1. The frequency of scraping increases with the fineness of the material and as the available head decreases.

2. The intermittent filters under the existing methods of operation required scraping less frequently than the continuous filters of the same construction, owing chiefly to a disturbance of the surface sand by the air which is driven from the pores of the filter.

3. These results confirm the conclusions drawn from the studies in 1892, except with regard to the effect of the method of application of water. This discrepancy is doubtless explained by the fact that Filters Nos. 35 A and 41 in 1892 contained, a foot or less from the surface, loam layers, which, together with the method of operation then practised, prevented much air from escaping at the surface.

4. As the filters grow old the sand becomes more compact. This compactness and the accumulation of matter from the water give the effect of a finer material, requiring more frequent scraping. (Filters Nos. 33A and 41 were disturbed to a depth of one foot in July, 1893, while No. 34 A was not treated in this manner.)

THE WATER TAKEN FROM THE MERRIMACK RIVER AND APPLIED TO THE EXPERIMENTAL FILTERS.

Water taken from the Merrimack River has been applied to all of the water filters, and is brought through a two-inch galvanized iron pipe, about four hundred feet long, from the north canal of the Essex Company. The water is substantially the same as the river water above Lawrence, which is applied to the city filter. The turbidity, sediment and odor are usually very slight, but after heavy rains and during the spring freshets the turbidity and sediment become very marked. The results of analyses are given in the two tables below. In the first table are given the analyses of the water as it was drawn from the pipe. From May 12 until the discontinuance of the experiments, December 8, cultures of *B. prodigiosus*, together with the food on which these germs grew, were applied to the water which supplied the several filters, for ten hours each day. The results of analyses of the water after its inoculation with these germs are given in the second table.

*Monthly Averages of Analyses of Canal Water (Merrimack River).**

[Parts per 100,000.]

DATE — 18[illegible].	Temperature, Degrees F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
January,	34	.41	.0085	.0207	.23	.019	.0001	.46	93.	11,200
February,	35	.35	.0164	.0225	.34	.022	.0002	.41	96.	7,200
March,	35	.38	.0061	.0204	.18	.020	.0001	.44	91.	4,800
April,	39	.44	.0022	.0146	.13	.011	.0000	.48	100.	2,700
May,	63	.46	.0038	.0166	.11	.016	.0000	.45	86.	2,400
June,	67	.37	.0070	.0190	.17	.016	.0000	.[illegible]	75.	[illegible]
July,	72	.36	.0095	.0214	.19	.020	.0002	.33	52.	[illegible]
August,	72	.29	.0097	.0210	.20	.018	.0001	.27	60.	4,100
September,	65	.30	.0080	.0170	.22	.016	.0001	.41	81.	18,600
October,	57	.34	[illegible]	.0201	.24	.012	.0003	.37	[illegible]	17,700
November,	42	.47	.0071	.0194	.19	.012	.0001	.58	95.	7,800
December,	34	.44	.0067	.0177	.20	.015	.0000	.49	98.	11,900

* For additional analyses, in which are given the residue on evaporation and observations upon the odor, turbidity and microscopical organisms, see page 181.

Monthly Averages of Weekly Analyses of Water as applied to Filters.

DATE —	Oxygen Consumed.	Bacteria per Cubic Centimeter. Water Bacteria.	Bacteria per Cubic Centimeter. Bacillus Prodigiosus.
May,	.47	2,400	8,300
June,	.40	5,900	5,000
July,	.34	4,600	6,900
August,	.28	4,100	5,900
Septembe[r]	.42	18,600	6,800
October,	.38	17,700	6,800
Novembe[r]	.54	7,800	6,100
Decembe[r]	.50	11,900	6,100

Detailed Account of the Work of the Several Water Filters in 1893.

The remaining pages contain a summary of the weekly averages of all bacterial results, followed by a brief description of the operation of each filter and monthly averages of both chemical and bacterial analyses. One bacterial sample was examined daily from each effluent from January until May. These results are more or less abnormal because the conditions existing in the filters were abnormal from time to time. This was caused partly by the formation of channels at the sides of the iron tanks due to freezing weather, and partly to the evolution of air by the water as it increased in temperature, which produced channels within the filters. These conditions were touched upon in the 1892 Report. It is believed that they would not appear in large filters in actual practice. On account of these peculiar and unfavorable circumstances the results obtained from January to May do not appear in the foregoing discussion, and for the same reason the experiments were discontinued during the winter of 1893–94.

General Plan of the Experiments.

Beginning May 12 *B. prodigiosus* was regularly applied to each filter for ten hours a day on six days in a week. The general plan of the experiments was the same as during the preceding year (see the 1892 Report, page 529). A pure culture of this species of bacteria was obtained by inoculation and growth for four days at 20° C. in a solution of one-tenth per cent. peptone and two-tenths per cent. glucose in city water. This solution was applied to the filters in the proportion of one part to three thousand parts of water, at intervals of one or two hours during the day, according to the rate of filtration. Throughout the experiments four examinations were made daily of each of the effluents, at a time when the water from the applied doses was passing through the outlet-pipes. The reasons that this species of bacteria was used are that it is easy to differentiate from ordinary water bacteria and is apparently very similar to the germ of typhoid fever [of Eberth] in its mode of life in the river water.

The experiments have been conducted with as much uniformity as possible, and the system practised has been substantially the same as that of the preceding year. Notes of the slight changes that have

been made will be found in the proper places. When considering the depths to which the filters were reduced, largely by scraping, it is to be borne in mind that this diminution is partly accounted for by settling. In November most of the filters were filled with water from below (in some cases very rapidly) after scraping, and this, together with the very high rates of filtration, increased the average number of bacteria in the effluents.

In the first table below will be found the results of the mechanical analyses of the sands in the various water filters. The underdrains were 5 inches deep in each case. Filters Nos. 3 B and 8 A are each one two-hundredth of an acre in area and are out of doors. The other water filters are 20 inches in diameter, equivalent to one twenty-thousandth of an acre, and are all placed within the buildings.

The second table beyond contains the weekly averages of the numbers of bacteria in the applied water and in the various effluents. Following this are brief descriptions and monthly averages of the chemical and bacterial analyses of the effluents of the several filters.

The report ends with a detailed account of the results of analyses obtained from the Lawrence city filter and also from the duplicate filters at the Experiment Station, Nos. 3 B and 8 A.

Mechanical Composition of Materials used for Water Filters in 1893.

Diameter in Millimeters.	Per Cent. by Weight of Grains in Filters Nos. —							
	18 A.	48.	44.	42.	45.	42.	41.	34 A.
Finer than 5.9,	100.0	100.0	-	-	-	-	-	-
" " 3.9,	97.0	96.0	-	98.0	98.0	-	100.0	-
" " 2.04,	93.0	72.0	98.0	85.0	95.0	100.0	99.0	-
" " .93,	32.0	45.0	78.0	54.0	91.0	97.0	96.0	100.0
" " .46,	8.0	17.0	32.0	26.0	50.0	87.0	70.0	99.0
" " .316,	4.0	5.0	12.0	14.0	22.0	44.0	38.0	94.0
" " .184,	1.3	0.9	3.7	5.4	5.5	9.0	15.0	52.0
" " .106,	0.0	0.2	0.8	1.4	0.9	0.4	5.4	11.2
" " .08,	-	-	-	-	-	-	-	3.0
" " .04,	-	-	-	-	-	-	-	0.5
Effective size (millimeter),	.48	.38	.29	.26	.23	.20	.14	.09
Uniformity co-efficient,	2.4	3.5	2.7	3.7	2.3	1.6	2.2	2.1
Estimated maximum rate (million gallons per acre daily).	184.0	116.0	67.0	53.0	42.0	32.0	16.0	7.0
Organic nitrogen (parts per 100,000),*	1.0	.8	.8	.8	.8	1.3	.8	.8

* Calculated as $\frac{14}{17}$ of the albuminoid ammonia doubled.

The "effective size" of the sand grains means that ten per cent. by weight of the grains are finer than the diameter given. The "uniformity coefficient" is the ratio A to B when the values of A and B are such that sixty per cent. by weight of the material is finer than A and ten per cent. finer than B. The "maximum rate" is the maximum quantity of water, expressed in million gallons per acre daily, which, at a temperature of 50° F., will pass through a filter of clean sand with no air in its pores, and with no suspended matter upon its surface when the acting head is equal to the depth of sand.

The sand in No. 48 is the same as in No. 49; No. 44 as in Nos. 46 and 47; No. 45 as in Nos. 3 B and 8 A; No. 42 as in Nos. 35 A, 36 A, 37, 38 and 39; and No. 41 the same as in No. 33 A.

The sand in No. 44 corresponds quite closely with the "No. 70" sand in the Lawrence city filter, and No. 45 with "No. 50" sand in the city filter.

Table showing the Number of Bacteria per Cubic Centimeter in the Applied Water and the Effluents from the Various Filters arranged as Weekly Averages of Daily Analyses.

Date. Week ending—	Bacteria in Applied Water.		Bacteria in Effluents from Filters Nos.— 18 A.		33 A.		34 A.		35 A.		36 A.		37.		38.		39.		41.		42.	
	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
1893.																						
Jan. 7, . .	19,200	0	1,028	-	81	-	188	-	531	-	579	-	1,218	-	1,026	-	835	-	717	-	716	-
14, . .	16,900	0	502	-	54	-	230	-	250	-	380	-	546	-	456	-	639	-	339	-	238	-
21, . .	4,800	0	136	-	103	-	164	-	401	-	635	-	63	-	160	-	289	-	234	-	145	-
28, . .	3,700	0	97	-	82	-	102	-	194	-	182	-	37	-	60	-	80	-	148	-	42	-
Feb. 4, . .	6,200	0	358	-	167	-	137	-	66	-	66	-	36	-	36	-	56	-	145	-	17	-
11, . .	7,500	0	248	-	118	-	183	-	718	-	476	-	302	-	367	-	492	-	342	-	180	-
19, . .	15,600	0	76	-	59	-	212	-	117	-	104	-	32	-	116	-	137	-	242	-	38	-
26, . .	478	0	69	-	59	-	58	-	108	-	48	-	31	-	102	-	89	-	36	-	37	-
March 5, . .	3,500	0	104	-	27	-	45	-	30	-	43	-	43	-	31	-	26	-	30	-	18	-
12, . .	4,600	0	72	-	31	-	39	-	33	-	57	-	48	-	65	-	56	-	83	-	26	-
19, . .	7,700	0	262	-	77	-	42	-	55	-	62	-	109	-	84	-	179	-	186	-	39	-
26, . .	4,200	0	57	-	39	-	26	-	65	-	16	-	22	-	22	-	73	-	45	-	16	-
April 2, . .	3,600	0	45	-	8	-	26	-	149	-	17	-	17	-	23	-	45	-	37	-	26	-
9, . .	3,400	0	29	-	10	-	25	-	37	-	19	-	21	-	19	-	29	-	39	-	28	-
16, . .	2,200	0	22	-	12	-	21	-	14	-	23	-	11	-	11	-	19	-	28	-	19	-
23, . .	2,400	0	14	-	13	-	7	-	35	-	9	-	15	-	14	-	13	-	20	-	17	-
30, . .	2,800	0	13	-	73	-	33	-	33	-	1	-	16	-	15	-	10	-	18	-	6	-
May 7, . .	4,200	0	22	-	21	-	44	-	44	-	11	-	14	-	17	-	103	-	18	-	29	-
13, . .	2,000	3,600	34	-	10	1.5	12	1.5	13	-	8	-	27	0	12	0.3	14	2.5	44	-	44	-
20, . .	1,900	2,700	18	-	10	0.3	11	2.0	7	-	9	-	8	0	14	0.9	36	10.3	10	0.5	17	1.9

Table of Weekly Averages of Bacteria in the Effluents from the various Filters — Continued.

Date. Week Ending — 1893.	Bacteria in Applied Water.		Bacteria in Effluents from Filters Nos. — 18 A.		33 A.		34 A.		35 A.		36 A.		37.*		38.		39.		41.		42.		43.		44.	
	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
May 27, .	2,000	3,700	20	-	7	5.3	8	0.9	5	-	13	-	5	0.2	9	2.6	20	8.8	7	2.7	9	0.7	1,339	67.0	391	74.0
June 3, .	2,700	5,200	30	-	10	1.3	8	2.3	31	-	18	-	8	0.2	12	1.0	23	4.5	10	1.2	12	1.8	541	20.0	172	24.0
10, .	7,000	6,500	18	-	10	0.8	11	1.6	9	-	15	-	17	0.4	12	1.0	75	4.5	11	2.1	22	1.6	287	3.8	118	8.0
17, .	7,000	5,400	12	-	12	0.6	8	1.0	5	0.4	11	0.3	9	3.1	8	1.2	13	7.1	6	0.2	9	1.0	292	-	51	-
24, .	4,300	11,100	11	-	6	0.1	6	0.1	9	2.6	4	0.0	14	3.0	9	0.7	31	12.9	11	2.5	15	3.4	225	-	50	-
July 1, .	7,400	5,000	17	-	29	0.8	21	0.0	14	3.0	22	0.4	Filter No. 45.†		39	1.7	23	13.5	12	1.3	15	2.5	292	-	46	-
8, .	5,500	6,900	28	-	15	4.2	34	0.8	17	1.0	64	11.0			31	3.5	62	20.3	17	1.8	17	9.0	140	5.2	23	3.8
15, .	5,200	6,000	63	-	48	1.4	15	1.2	31	0.4	52	1.6	1,586	92.0	55	3.9	455	43.0	30	1.7	23	1.6	63	4.0	44	6.0
22, .	5,000	6,700	316	67.0	23	2.6	33	2.0	76	10.0	78	4.0	279	140.2	80	8.0	338	109.0	40	7.0	132	5.4	38	8.4	30	13.0
29, .	3,500	9,100	128	50.0	306	2.2	15	1.2	88	9.0	234	8.2	177	52.2	341	4.8	595	178.0	47	7.0	318	6.0	58	5.2	19	7.5
Aug. 5, .	4,100	7,500	119	41.0	54	4.7	19	3.3	54	11.0	70	1.8	155	52.0	28	6.5	804	181.5	49	12.3	83	4.2	33	11.2	25	11.5
12, .	4,800	5,800	90	28.5	90	1.7	14	1.7	22	4.7	161	1.1	81	19.0	153	3.8	284	62.5	30	4.3	38	3.3	29	5.0	19	2.4
19, .	3,500	5,500	86	39.2	51	1.7	31	1.6	19	1.4	84	6.5	62	30.0	58	3.7	43	29.2	32	7.2	20	3.7	23	6.0	40	11.0

* Filter No. 37 was discontinued on June 26, 1893.

† Filter No. 45 was started July 10, 1893.

Table of Weekly Averages of Bacteria in the Effluents from the various Filters — Concluded.

Date. Week Ending — 1893.	Bacteria in Applied Water		Bacteria in Effluents from Filters Nos. — 16 A.		33 A.		38.		41.		42.		43.		44.		45.		46.		34 A.		35 A.		36 A.	
	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.	Water Bacteria.	Bacillus Prodigiosus.
Aug. 26,	3,700	6,300	307	32.5	149	2.7	156	1.5	15	2.7	119	1.8	18	3.6	40	4.8	107	21.0	619	150.0	86	1.1	8	0.8	363	0.7
Sept. 2,	3,600	4,200	137	3.3	190	0.3	24	0.2	68	0.6	16	0.1	19	0.4	22	0.3	66	3.0	65	1.3	44	0.3	23	0.1	126	3.0
9,	5,800	5,500	337	1.6	26	1.5	18	1.0	26	1.3	9	0.5	10	0.6	4	0.5	185	7.6	51	4.0	24	0.3	13	0.3	30	1.0
																					Filter No. 47.		Filter No. 48.		Filter No. 49.	
16,	17,000	9,000	263	13.3	30	3.7	14	1.4	17	1.6	41	8.0	11	2.4	9.0	1.0	153	9.5	35	3.2	1,630	371.0	1,912	244.2	647	46.0
23,	9,800	8,700	140	4.5	20	1.0	13	0.3	51	9.0	13	1.3	15	1.3	8.5	0.8	129	6.8	57	2.5	1,233	78.3	1,151	99.5	236	1.8
30,	41,900	4,900	7,667	36.0	120	1.4	40	0.5	96	1.9	37	0.7	171	4.5	169.0	2.5	2,143	16.2	212	5.0	3,671	55.0	6,547	51.5	111	4.7
Oct. 7,	18,600	6,400	1,473	74.3	64	0.8	25	0.2	34	1.1	18	0.7	45	1.3	22.0	0.3	1,186	28.5	69	4.2	1,436	18.5	843	62.0	186	3.3
14,	36,600	7,100	2,308	101.0	46	0.1	42	0.1	20	0.4	14	0.5	30	0.9	15.0	0.5	188	8.2	34	2.6	607	24.0	885	42.0	87	3.0
21,	10,200	6,900	167	17.0	24	0.0	22	0.1	11	0.2	11	0.1	24	0.6	14.0	0.5	114	9.0	26	3.7	274	15.0	320	25.0	87	9.0
28,	9,700	6,500	59	16.0	26	0.1	25	0.0	14	0.5	10	0.0	94	26.0	37.0	6.5	56	8.0	85	5.0	71	13.0	81	14.0	85	11.0
Nov. 4,	6,400	7,000	63	22.0	17	0.0	25	0.1	10	0.5	13	0.4	35	13.0	27.0	10.0	63	11.0	20	6.0	62	24.0	83	27.0	56	18.0
11,	5,400	5,500	58	10.0	20	0.6	27	1.7	11	0.5	9	0.2	71	9.0	57.0	5.0	107	12.0	122	15.0	180	25.0	182	28.0	93	9.0
18,	6,500	5,900	38	6.0	16	0.6	95	15.1	12	0.3	56	14.5	45	12.0	42.0	7.0	38	7.5	155	37.2	154	30.5	133	33.0	86	26.0
25,	10,900	6,500	61	4.3	27	0.9	92	3.8	7	0.0	240	14.0	225	7.0	154.0	11.0	105	14.0	354	11.1	541	47.0	93	16.0	39	3.2
Dec. 2,	11,100	6,300	318	17.0	64	2.4	53	1.6	10	0.0	87	4.7	234	13.4	201.0	14.0	286	18.0	205	17.0	276	25.0	128	10.0	87	6.0
8,	11,100	6,400	1,004	57.2	422	25.0	60	2.2	26	1.6	83	6.0	1,166	60.0	326.0	29.0	621	34.4	254	18.0	716	46.2	861	46.0	163	7.0

NOTE. — About the first of December channels were formed at the sides of the iron tanks and the experiments were discontinued for the winter on December 8.

Filter No. 18 A.

This filter, 20 inches in diameter, contains sand of an effective size of 0.48 millimeter and has been in operation since Sept. 17, 1889. The original depth of the sand was 62 inches. Up to January, 1891, city water was applied in hourly doses, fourteen hours a day on six days a week, at the rate of about one million gallons per acre daily. The faucet at the outlet was always kept wide open until Oct. 1, 1893, and the rate of filtration regulated at the top. The outlet has never been trapped. With the exception of a few scattering days river water taken from the canal has been applied since Aug. 18, 1891. From January, 1891, to July, 1893, the water was applied by an automatic arrangement in small doses equivalent to 5,000 gallons per acre once in three to seven minutes, days, nights and Sundays, according to the rate of filtration. On July 17, 1893, the siphon attachment, by which the water was applied intermittently, was removed and the water applied constantly for sixteen hours a day on six days in a week. Beginning October 1 the faucet at the outlet was closed at 5 A.M. daily after draining over night and the water applied at the top; after the surface was covered the faucet was opened below to give the desired rate of filtration, and the surface was kept covered until the water was shut off at 9 P.M. With the exception of November 21 to 30 this method was followed through the rest of the year.

No sand was scraped from the surface until November, 1892, when it was necessary to remove 2½ inches in order to keep the action of the filter intermittent. During the four years of its operation the surface was scraped five times and 8 inches of sand were removed without replacement; the water filtered in this time was equivalent to 1,500,000,000 gallons per acre. The sand removed was equivalent to 0.70 cubic yard per million gallons of water filtered. It will be seen that this quantity agrees approximately with some of the results from other filters presented on page 487. On October 9 clean sand was added and the filter restored to its original depth.

Monthly Averages of Analyses of Effluent of Filter No. 18 A.

[Parts per 100,000.]

DATE—1893.	Quantity of Effluent. — Gallons per Acre Daily.	TEMPERATURE. DEG. F.		Color.	AMMONIA.		Chlorine.	NITROGEN AS		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.*	BACTERIA PER CUBIC CENTIMETER.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January,	1,660,000	34	36	.29	.0080	.0104	.29	.0300	.0002	.32	98	614	-
February,	1,680,000	35	36	.27	.0083	.0115	.25	.0280	.0005	.31	98	244	-
March,	1,840,000	35	35.5	.27	.0049	.0084	.17	.0200	.0002	.37	98	90	-
April,	1,380,000	39	42.7	.33	.0021	.0095	.12	.0210	.0000	.31	100	20	-
May,	1,530,000	58	53.3	.41	.0021	.0108	.10	.0270	.0000	.40	97	24	-
June,	2,300,000	67	68	.29	.0018	.0093	.16	.0290	.0000	.29	91	18	-
July,	1,680,000	72	68	.25	.0017	.0109	.20	.0410	.0000	.24	98	222	58
August,	1,920,000	72	71.6	.17	.0022	.0096	.20	.0310	.0000	.18	92	148	29
September,	1,740,000	65	65	.24	.0017	.0117	.22	.0260	.0002	.28	89	2,375	19
October,	1,640,000	57	55	.36	.0025	.0137	.23	.0230	.0000	.43	96	1,002	52
November,	1,760,000	42	43.7	.34	.0024	.0124	.20	.0230	.0003	.39	100	167	11
December,	4,120,000	34	34	.41	.0060	.0144	.20	.0220	.0002	.48	100	1,004	57

* In all cases the dissolved oxygen is expressed as per cent. of the amount required to saturate the water at the temperature when collected.

FILTER No. 33 A.

This filter was put in operation April 28, 1892, and contains sand of an effective size of 0.14 millimeter. The original depth was 60 inches. The method of operation has been continuous, except from April 17 to 30, 1893, and for a few days at irregular intervals during the winter, when the filter was accidentally drained, owing to freezing of the water pipes. The rate of filtration has been regulated by the faucet at the outlet, to which a trap is attached. From May 25 to December 8 the filter was scraped 8 times, an average of once in 23 days. The average depth removed at a scraping was 0.23 inch; the average quantity filtered between scrapings was equivalent to 49 million gallons per acre, and the sand removed was equivalent to 0.63 cubic yard per million gallons. On July 17 the upper foot of sand was removed and replaced, as was described on page 465. Until October 6 the sand removed by scraping was not replaced, but on that date the depth was restored from 47 inches to its original depth of 60 inches. After this date the sand was replaced at the time of scraping.

Monthly Averages of Analyses of Effluent of Filter No. 33 A.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, .	1,540,000	34	37	.27	.0040	.0096	.29	.0300	.0000	.30	79	81	-
February, .	1,840,000	35	37	.27	.0034	.0082	.19	.0225	.0000	.28	71	118	-
March, . .	1,860,000	35	38	.25	.0019	.0078	.17	.0185	.0000	.32	69	30	-
April, . .	1,660,000	39	45	.33	.0007	.0096	.11	.0215	.0000	.33	76	27	-
May, . .	1,720,000	53	53	.41	.0011	.0095	.10	.0185	.0000	.42	55	8	0.7
June, . .	1,740,000	67	68	.28	.0011	.0087	.15	.0335	.0000	.29	38	15	0.7
July, . .	1,860,000	72	68	.22	.0015	.0096	.19	.0347	.0000	.21	8	98	2.5
August, .	2,700,000	72	69	.17	.0023	.0098	.20	.0297	.0018	.16	12	107	2.2
September, .	1,920,000	65	62	.22	.0020	.0094	.21	.0290	.0000	.26	31	53	2.0
October, .	1,940,000	57	55	.23	.0023	.0102	.24	.0262	.0000	.29	54	39	0.3
November, .	2,780,000	42	44	.35	.0025	.0107	.18	.0223	.0000	.39	81	29	0.9
December, .	4,000,000	34	35	.37	.0068	.0118	.20	.0210	.0000	.43	87	422	25.0

Filter No. 34 A.

This filter contained sand of an effective size of 0.09 millimeter, and its original depth was 60 inches. It was operated continuously after it was first put in operation, April 28, 1892. The rate of filtration was regulated at the outlet by a faucet to which a trap was attached.

From May 12 to September 7, 1893, the date of its discontinuance, the surface was scraped 17 times to relieve clogging. It was scraped on an average once in 7 days. The average depth removed was 0.12 inch; the average quantity of water filtered between scrapings was equivalent to 14 million gallons per acre, and the sand removed was equivalent to 1.16 cubic yards per million gallons. The depth of sand at the date of its discontinuance was 44 inches.

Monthly Averages of Analyses of Effluent of Filter No. 34 A.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, .	1,340,000	34	37	.27	.0051	.0101	.30	.0250	.0000	.31	73	200	-
February, .	1,620,000	35	37.3	.29	.0054	.0098	.20	.0230	.0000	.31	74	147	-
March, . .	1,520,000	35	39	.26	.0035	.0066	.18	.0200	.0000	.31	80	30	-
April, . .	1,320,000	39	45.3	.33	.0013	.0109	.12	.0230	.0000	.39	75	22	-
May, . .	1,560,000	53	55.3	.40	.0009	.0093	.11	.0210	.0000	.42	65	9	1.7
June, . .	1,420,000	67	68.3	.30	.0036	.0104	.16	.0290	.0000	.28	54	12	0.8
July, . .	1,860,000	72	67.5	.20	.0012	.0104	.19	.0290	.0010	.22	22	24	1.2
August, .	2,300,000	72	70.5	.16	.0017	.0091	.20	.0260	.0000	.17	18	39	1.6

Filter No. 35 A.

This filter was constructed on March 30, 1892, and contained sand of an effective size of 0.20 millimeter. The original depth was 57.5 inches, and 1 foot below the surface was a layer of loam 1 inch thick. April 17 to 30 and July 31 to September 6, 1893, it was operated continuously with the trap attached to the outlet in the usual manner. During the remainder of the time it was operated intermittently, with the untrapped faucet at the outlet wide open and the rate regulated at the top. The water was applied sixteen hours a day on six days in a week. On July 17, when the layer of loam was less than 3 inches below the surface, the sand was taken out down to the loam, which was removed and the sand replaced.

From May 24 to September 7, the date of its discontinuance, the surface was scraped three times to relieve clogging, and the average depth removed was 0.25 inch. The average quantity of water filtered between scrapings was equivalent to 92 million gallons per acre. It was scraped on an average once in 33 days, and the sand removed was equivalent to 0.36 cubic yard per million gallons.

The depth of the sand on September 7 was 49 inches.

Monthly Averages of Analyses of Effluent of Filter No. 35 A.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, .	960,000	34	37.8	.24	.0065	.0071	.27	.0380	.0000	.26	96	398	-
February, .	860,000	35	37.8	.28	.0060	.0081	.19	.0290	.0000	.25	74	399	-
March, . .	920,000	35	39.5	.28	.0024	.0094	.17	.0230	.0000	.35	100	55	-
April, . .	1,580,000	39	44.3	.35	.0010	.0093	.13	.0170	.0000	.38	94	30	-
May, . .	1,400,000	53	55.3	.38	.0020	.0097	.11	.0400	.0000	.38	91	17	-
June, . .	1,180,000	67	72.0	.28	.0027	.0086	.16	.0580	.0000	.26	84	9	1.9
July, . .	1,680,000	72	71.1	.21	.0013	.0097	.19	.0410	.0000	.21	89	53	5.0
August, .	2,960,000	72	70.2	.15	.0021	.0089	.20	.0340	.0001	.16	50	22	3.6

Filter No. 36 A.

This filter was constructed on the same date and in the same manner as No. 35 A. It was operated continuously, except from April 17 to 30 and from July 31 to September 7, when it was operated intermittently in the same manner as No. 35 A.

From May 12 to September 7, 1893, the date of its discontinuance, the surface was scraped 7 times to relieve clogging, and the average depth removed was 0.21 inch. The average quantity of water filtered between scrapings was equivalent to 35 million gallons per acre. It was scraped on an average once in 14 days, and the sand removed was equivalent to 0.82 cubic yard per million gallons.

The depth of sand on September 6 was 48 inches.

Monthly Averages of Analyses of Effluent of Filter No. 36 A.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, .	1,480,000	34	37.5	.25	.0060	.0075	.27	.0300	.0000	.29	69	530	-
February, .	1,540,000	35	36.5	.28	.0029	.0090	.19	.0290	.0000	.31	65	278	-
March, . .	1,880,000	35	38.0	.26	.0018	.0090	.17	.0240	.0000	.33	66	33	-
April, . .	1,600,000	39	43.5	.36	.0007	.0119	.13	.0310	.0000	.35	86	13	-
May, . .	2,020,000	53	54.3	.38	.0018	.0101	.11	.0230	.0000	.41	71	10	-
June, . .	2,060,000	67	68.7	.28	.0016	.0088	.17	.0390	.0000	.27	64	12	0.3
July, . .	3,040,000	72	68.8	.22	.0021	.0097	.20	.0300	.0006	.23	15	107	6.0
August, .	1,660,000	72	70.4	.16	.0024	.0091	.20	.0490	.0000	.16	86	157	3.5
September, .	1,200,000	65	63.0	.23	.0008	.0088	.21	.0330	.0000	.31	-	30	1.0

Filter No. 37.

This filter was constructed on April 18, 1892, and contained originally 61 inches in depth of sand having an effective size of 0.20 millimeter. It was operated continuously until June 25, 1893, when the experiment was discontinued, owing to an accident which happened to the tank.

The results obtained from this filter are more or less affected by evolution of air from the water and the formation of channels at the sides of the iron tank, as is indicated by the results of the analyses below and by the fact that this filter of medium fine sand was operated for more than three months during the winter without scraping. It was scraped on June 19 to relieve clogging, and 0.20 inch was removed. The depth of sand on this date was 55 inches.

Monthly Averages of Analyses of Effluent of Filter No. 37.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, . .	1,780,000	34	36	.26	.0091	.0082	.29	.0270	.0000	.27	70	460	-
February, .	1,740,000	35	36	.28	.0085	.0101	.25	.0230	.0001	.29	72	168	-
March, . .	2,000,000	35	37.8	.25	.0022	.0079	.17	.0230	.0000	.32	75	39	-
April, . .	1,640,000	39	43	.34	.0010	.0116	.12	.0180	.0000	.35	69	18	-
May, . .	1,680,000	53	55	.38	.0013	.0093	.11	.0200	.0000	.40	56	7	0.0
June, . .	3,360,000	67	68	.29	.0022	.0098	.16	.0270	.0000	.29	62	13	1.9

Filter No. 38.

This filter contained sand of an effective size of 0.20 millimeter, and its original depth was 24 inches. The date of its construction was April 28, 1892. It has been operated continuously in the usual manner.

From May 25 to December 4 the surface was scraped 18 times to relieve clogging. It was scraped on an average once in 11 days. The average depth removed was 0.17 inch; the average quantity of water filtered between scrapings was equivalent to 22 million gal-

lons per acre, and the sand removed was equivalent to 1.06 cubic yards per million gallons.

The sand removed by scraping was not replaced with clean material until Sept. 12, 1893. The depth of sand was about 14 inches on that date, when the filter was refilled to its original depth. From this time on the sand was replaced at the time of scraping. The addition of new sand in September caused a greater (percentage) removal of color.

Monthly Averages of Analyses of Effluent of Filter No. 38.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January,	1,680,000	34	35	.28	.0076	.0086	.23	.0170	.0000	.31	79	500	-
February,	1,780,000	36	35	.30	.0084	.0112	.22	.0215	.0000	.35	78	188	-
March,	1,980,000	35	35.5	.29	.0032	.0084	.18	.0207	.0000	.34	82	38	-
April,	1,540,000	39	41	.37	.0018	.0102	.11	.0135	.0000	.38	73	17	-
May,	1,900,000	53	55.5	.39	.0011	.0104	.10	.0250	.0000	.39	68	12	1.3
June,	1,660,000	67	69	.30	.0015	.0090	.16	.0360	.0000	.29	43	17	1.2
July,	1,940,000	72	70	.20	.0024	.0095	.20	.0307	.0006	.22	21	127	5.0
August,	2,540,000	72	70.5	.16	.0023	.0090	.20	.0240	.0000	.16	27	84	3.3
September,	1,940,000	65	63	.12	.0016	.0079	.22	.0310	.0000	.14	60	22	0.7
October,	1,980,000	57	55	.30	.0025	.0115	.23	.0237	.0000	.37	47	29	0.1
November,	3,380,000	42	42	.33	.0028	.0124	.19	.0225	.0000	.37	83	58	4.5
December,	3,900,000	34	35.5	.38	.0054	.0112	.20	.0190	.0000	.41	82	60	2.2

Filter No. 39.

The filter contained sand of an effective size of 0.20 millimeter. Its depth on the date of its construction, April 28, 1892, was 12 inches. It was operated continuously up to Aug. 19, 1893, the date of its discontinuance, with the exception of July 10 to 30, when it was operated intermittently with the outlet untrapped and wide open. The depth of sand May 1, 1893, was 2.5 inches. From May 12 to August 19 the surface was scraped 14 times to relieve clogging, and the average depth removed was 0.15 inch. The average quantity of water filtered between scrapings was equivalent to 13 million gal-

lons per acre. It was scraped on an average once in 7 days, and the sand removed was equivalent to 1.55 cubic yards per million gallons.

The depth of sand in the filter at the time the experiment was brought to an end was about 0.5 inch. In addition to this, however, there were 5 inches of underdrains, some of the material of which was fairly fine.

Monthly Averages of Analyses of Effluent of Filter No. 39.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, .	1,620,000	34	35	.26	.0076	.0112	.24	.0180	.0000	.33	79	893	-
February, .	1,780,000	35	35.3	.30	.0082	.0107	.22	.0210	.0000	.36	86	251	-
March, . .	1,900,000	35	34.7	.31	.0063	.0102	.18	.0220	.0000	.38	84	63	-
April, . .	1,540,000	39	41.5	.37	.0037	.0107	.11	.0120	.0000	.38	85	18	-
May, . .	1,980,000	53	56.5	.39	.0017	.0104	.10	.0220	.0000	.42	50	19	4
June, . .	1,580,000	67	69	.31	.0010	.0091	.16	.0300	.0000	.32	38	35	9
July, . .	1,480,000	72	73	.22	.0019	.0142	.21	.0270	.0000	.26	62	352	82
August, .	1,740,000	72	70.2	.19	.0019	.0120	.20	.0230	.0000	.19	55	318	89

Filter No. 41.

This filter, a duplicate of No. 33 A, was constructed May 9, 1892, and contained originally 60 inches in depth of sand of an effective size of 0.14 millimeter. It has been operated intermittently, except from April 17 to 30, with the outlet untrapped. On July 17 the upper foot of material was dug out and put back (see page 465). Up to Oct. 1, 1893, the faucet at the outlet was kept wide open and the rate of filtration regulated at the top. During the rest of the year, except November 21 to 30, it was operated as follows: the faucet at the outlet was closed at 5 A.M. daily, after the filter had been allowed to drain over night, and the water applied at the top; after the surface was covered the faucet was opened at the outlet to give the desired rate of filtration, and the surface was kept covered until the water was shut off at 9 P.M.

From May 12 to December 8 the surface was scraped 8 times to

relieve clogging, — an average of once in 22 days. The average depth removed at a scraping was 0.19 inch; the average quantity of water filtered between scrapings was equivalent to 56 million gallons per acre; and the sand removed was equivalent to 0.46 cubic yard per million gallons.

Until Nov. 15, 1893, the sand removed by scraping was not replaced with new material, but on that date the depth was restored from 52 inches to its original depth of 60 inches. After this date the sand was replaced at the time of scraping.

Monthly Averages of Analyses of Effluent of Filter No. 41.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
January, .	1,660,000	34	37	.26	.0050	.0094	.23	.0170	.0000	.32	99	508	-
February, .	1,660,000	35	37	.28	.0088	.0091	.23	.0285	.0000	.28	99	280	-
March, . .	1,500,000	35	39.5	.28	.0045	.0080	.17	.0180	.0000	.32	100	64	-
April, . .	1,840,000	39	45	.33	.0005	.0083	.11	.0140	.0000	.33	95	26	-
May, . .	2,060,000	53	58	.39	.0017	.0095	.10	.0134	.0000	.39	89	9	1.5
June, . .	1,460,000	67	69.8	.30	.0014	.0104	.16	.0255	.0000	.30	51	10	1.5
July, . .	2,020,000	72	73.5	.21	.0027	.0105	.20	.0407	.0000	.22	91	33	4.4
August, .	1,900,000	72	68.7	.17	.0018	.0097	.20	.0364	.0000	.16	79	39	5.4
September, .	1,940,000	65	65	.24	.0019	.0105	.21	.0267	.0000	.30	86	48	2.9
October, .	1,800,000	57	55.8	.24	.0021	.0099	.24	.0254	.0000	.29	94	19	0.5
November, .	1,560,000	42	45.6	.33	.0019	.0115	.18	.0237	.0000	.40	93	10	0.3
December, .	1,200,000	34	35.5	.36	.0024	.0114	.20	.0270	.0000	.39	96	26	1.6

Filter No. 42.

This filter was started on Oct. 29, 1892, and contained 13 inches in depth of sand of an effective size of 0.20 millimeter. It has been operated continuously in the usual manner. The depth of sand in May, 1893, was 10 inches.

From May 12 to December 8 the surface was scraped 24 times to relieve clogging. It was scraped on an average once in 7 days. The average depth removed was 0.16 inch; the average quantity of water filtered between scrapings was equivalent to 19 million gal-

lons per acre; and the sand removed was equivalent to 1.11 cubic yards per million gallons.

The sand removed by scraping was not replaced with clean material until September 9. The depth of sand was then about 7 inches, and the filter was refilled to its original depth. From this time on the sand was replaced at the time of scraping. The addition of new material in September caused a greater (percentage) removal of color.

Monthly Averages of Analyses of Effluent of Filter No. 42.

[Parts per 100,000.]

Date—[redacted].	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Bacillus Prodigiosus.
January, .	1,650,000	34	36	.30	.0068	.0114	.23	.0150	.0000	[redacted]	85	–
February, .	1,740,000	35	35	.30	.0060	.0105	.22	.0205	[redacted]	.34	90	–
March, . .	1,920,000	35	[redacted]	.31	.0056	.0107	.16	.0190	.0000	[redacted]	96	–
April, . .	1,560,000	39	42	.37	.0027	.0106	.11	[redacted]	[redacted]	.36	85	–
May, . .	1,920,000	53	56.5	.41	.0006	.0100	.10	[redacted]	.0000	.41	74	1.5
June, . .	1,660,000	67	69	.30	.0021	.0095	.16	.0310	.0000	[redacted]	68	1.5
July, . .	1,920,000	72	71	[redacted]	.0027	.0108	.21	.0313	.0002	.23	11	5.5
August, .	1,860,000	72	69	.14	.0018	.0083	.20	.0247	.0004	.17	42	2.8
September, .	1,780,000	65	64	.15	.0016	.0097	.22	.0255	.0000	.22	66	2.8
October, .	1,980,000	57	55	.32	.0018	.0121	.23	.0223	.0000	[redacted]	64	1.4
November, .	1,880,000	42	43.5	.31	.0022	.0109	.19	.0240	.0000	[redacted]	81	7.0
December, .	[redacted]	34	35.5	.37	.0030	.0114	.20	.0240	.0000	.41	82	6.0

Filter No. 43.

This filter was started on May 20, 1893, and contained 60 inches in depth of sand of an effective size of 0.26 millimeter. It has been operated continuously.

From May 20 to December 8 it was scraped 16 times. This was an average of once in 10 days. The average depth removed was 0.26 inch, and the average quantity of water filtered between scrapings was equivalent to 57 million gallons per acre. The sand removed was equivalent to 0.63 cubic yard per million gallons.

The sand removed up to October 13 was replaced with clean material on that date, and after that time the sand was replaced at the time of scraping.

Monthly Averages of Analyses of Effluent of Filter No. 43.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F. — Applied Water.	Temperature. Deg. F. — Effluent.	Color.	Ammonia. — Free.	Ammonia. — Albuminoid.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter. — Water Bacteria.	Bacteria per Cubic Centimeter. — Bacillus Prodigiosus.
May, . .	2,200,000	53	56	.45	.0028	.0109	.15	.0160	.0000	.29	100	1,042	53.0
June, . .	3,920,000	67	66	.33	.0025	.0109	.18	.0257	.0000	.29	74	316	6.0
July, . .	2,820,000	72	69	.20	.0020	.0111	.20	.0290	.0000	.23	29	72	5.5
August, .	4,260,000	72	67	.14	.0015	.0098	.20	.0245	.0000	.17	33	26	5.0
September, .	4,540,000	65	65	.32	.0015	.0112	.22	.0263	.0000	.39	49	57	2.4
October, .	4,820,000	57	57	.26	.0022	.0113	.24	.0264	.0000	.30	60	46	8.4
November, .	7,600,000	42	44	.35	.0064	.0119	.18	.0213	.0000	.41	81	124	11.0
December, .	9,340,000	34	35	.41	.0098	.0144	.20	.0180	.0000	.48	86	1,166	60.0

Filter No. 44.

This filter was put in operation, continuously, May 20, 1893, and contained 60 inches in depth of sand of an effective size of 0.29 millimeter. The sand removed by scraping up to October 27 was replaced on that date, and after that time the sand was replaced with clean material at the time of its removal.

From May 20 to December 8 the surface was scraped 13 times to relieve clogging, and the average depth removed was 0.30 inch. The average quantity of water filtered between scrapings was equivalent to 70 million gallons per acre. It was scraped on an average once in 13 days, and the sand removed was equivalent to 0.58 cubic yard per million gallons.

Monthly Averages of Analyses of Effluent of Filter No. 44.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F. — Applied Water.	Temperature. Deg. F. — Effluent.	Color.	Ammonia. — Free.	Ammonia. — Albuminoid.	Chlorine.	Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter. — Water Bacteria.	Bacteria per Cubic Centimeter. — Bacillus Prodigiosus.
May, . .	2,200,000	53	56	.45	.0036	.0118	.14	.0160	.0000	.32	98	318	57.0
June, . .	2,840,000	67	66	.35	.0018	.0106	.17	.0252	.0000	.29	75	128	12.0
July, . .	2,820,000	72	69	.28	.0017	.0108	.20	.0285	.0005	.23	38	29	7.0
August, .	4,840,000	72	67	.14	.0019	.0097	.20	.0400	.0000	.16	59	29	6.0
September, .	4,660,000	65	66	.32	.0019	.0116	.21	.0267	.0000	.36	46	58	1.3
October, .	5,840,000	57	57	.26	.0026	.0110	.24	.0274	.0000	.31	71	22	1.9
November, .	7,620,000	42	44	.35	.0065	.0122	.18	.0197	.0000	.41	80	96	9.0
December, .	9,300,000	34	35.5	.40	.0094	.0138	.20	.0190	.0000	.46	83	326	29.0

Filter No. 45.

This filter was constructed July 10, 1893, and contained 60 inches in depth of sand of an effective size of 0.23 millimeter. It has been operated intermittently after the same method that was used in the case of No. 41 (see page 503). With respect to size of sand grains it resembles most closely the continuous filter No. 43.

From July 10 to December 8 the surface was scraped 4 times. This was an average of once in 35 days. The average depth removed was 0.28 inch, and the average quantity of water filtered between scrapings was equivalent to 78 million gallons per acre. The sand removed was equivalent to 0.48 cubic yards per million gallons.

The sand removed up to October 27 was replaced with clean material on that date, and after that time the sand was replaced at the time of scraping.

Monthly Averages of Analyses of Effluent of Filter No. 45.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature Deg. — Applied Water.		Nitrogen as — Nitrates.	Nitrogen as — Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter. — Water Bacteria.	Bacteria per Cubic Centimeter. — Bacillus Prodigiosus.
July,	1,500,000	72	2	.0243	.0000	.22	97	690	92
August,	1,920,000	72	0	.0258	.0000	.17	96	92	25
September,	1,740,000	66	1	.0227	.0000	.44	98	725	6
October,	1,800,000	57	4	.0275	.0000	.25	98	39	12
November,	3,560,000	42	9	.0170	.0000	.41	97	119	12
December,	5,760,000	34	0	.0180	.0000	.47	98	821	84

Filter No. 46.

This filter was put in operation Aug. 21, 1893, and contained 12 inches of sand of an effective size of 0.29 millimeter. This sand was from the same lot as that used for No. 44. It has been operated continuously. From August 21 to December 8 the surface was scraped 9 times to relieve clogging, and the average depth removed was 0.25 inch. The average quantity of water filtered between scrapings was equivalent to 29 million gallons per acre. It was scraped on an average once in 11 days, and the sand removed was equivalent to 1.16 cubic yards per million gallons.

Monthly Averages of Analyses of Effluent of Filter No. 46.

[Parts per 100,000.]

					Ammonia.			Nitrogen as				Bacteria per Cubic Centimeter.	
				Color.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Water Bacteria.	Bacillus Prodigiosus.
August, .	2,040,000	72	68	.20	.0029	.0120	.20	.0246	.0000	.20	64	65	1.3
September, .	1,920,000	65	64	.28	.0014	.0130	.22	.0256	[illegible]	.35	49	98	3.3
October, .	2,240,000	57	57	.22	.0021	.0106	.24	.0270	.0000	.26	67	41	16.0
November, .	3,600,000	42	45	.39	[illegible]	.0127	.20	.0183	[illegible]	.47	81	171	17.0
December, .	4,180,000	34	35	.37	.0092	.0126	.20	.0180	[illegible]	.46	85	284	18.0

Filter No. 47.

This filter was put in operation Sept. 8, 1893, and contained 60 inches in depth of sand of an effective size of 0.29 millimeter. The sand was of the same size and from the same lot as that of No. 44. It has been operated intermittently in the same manner as No. 41 (see page 503).

From September 8 to December 8 it was scraped twice, an average of once in 42 days. The average depth removed was 0.45 inch, and the average quantity of water filtered between scrapings was equivalent to 100 million gallons per acre. The sand removed was equivalent to 0.60 cubic yard per million gallons.

Monthly Averages of Analyses of Effluent of Filter No. 47.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.			Ammonia.			Nitrogen as				Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.	Color.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Water Bacteria.	Bacillus Prodigiosus.
September, .	1,740,000	65	64	.33	.0027	.0144	.22	.0160	.0001	.35	99	2,296	176
October, .	1,800,000	57	56	.28	.0016	.0134	.24	[illegible]	.0003	.27	99	596	18
November, .	3,590,000	42	44	.41	.0026	.0138	.19	.0162	.0002	.46	97	213	25
December, .	6,860,000	34	35.5	.40	.0072	[illegible]	[illegible]	.0160	.0010	.47	96	716	46

Filter No. 48.

This filter was put in operation Sept. 9, 1893, and contained 60 inches in depth of sand of an effective size of 0.38 millimeter. It has been operated intermittently in the same way as No. 41 (see page 503).

Up to December 8 it was scraped but once, — 71 days after it was first put in operation. The depth removed was 0.88 inch, which was equivalent to 0.66 cubic yard per million gallons of water. The quantity filtered up to the time of the scraping was equivalent to 181 million gallons per acre.

Monthly Averages of Analyses of Effluent of Filter No. 48.

[Parts per 100,000.]

Date—1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus.
September, .	1,760,000	65	64	.35	.0029	.0138	.22	.0145	.0004	.36	99	3,050	136
October, .	1,800,000	57	57	.30	.0020	.0132	.24	.0267	.0000	.26	100	663	33
November, .	2,920,000	42	45	.43	.0026	.0133	.19	.0172	.0002	.46	98	123	23
December, .	2,960,000	34	36	.40	.0060	.0146	.20	.0240	.0006	.46	100	861	46

Filter No. 49.

This filter, a duplicate of No. 48, was put in operation Sept. 9, 1893. It has been operated continuously. Up to December 8 the surface was scraped 4 times, an average of once in 37 days. The average depth removed was 0.32 inch, and the average quantity of water filtered between scrapings was equivalent to 79 million gallons per acre. The sand removed was equivalent to 0.53 cubic yard per million gallons.

Monthly Averages of Analyses of Effluent of Filter No. 49.

[Parts per 100,000.]

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Deg. F.		Color.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Bacteria per Cubic Centimeter.	
		Applied Water.	Effluent.		Free.	Albuminoid.		Nitrates.	Nitrites.			Water Bacteria.	Bacillus Prodigiosus
September, .	2,060,000	65	62	.38	.0029	.0142	.22	.0165	.0000	.31	69	344	19
October, .	2,600,000	57	57	.26	.0013	.0102	.24	.0265	.0000	.26	61	112	7
November, .	5,260,000	42	44	.41	.0038	.0182	.19	.0170	.0001	.45	88	72	12
December, .	5,600,000	34	36	.41	.0070	.0138	.20	.0230	.0002	.46	89	163	7

Filters Nos. 3 B and 8 A.

These filters are each one two-hundredth of an acre in area, and contain 5 feet in depth of sand of an effective size of 0.23 millimeter. This sand was taken from the same place as that which was used in the construction of the Lawrence city filter, and in size it is very similar to a large proportion of the sand in the city filter. The maximum rate at which this sand will allow water to pass, when the acting head is equal to the depth of the sand, is estimated at 43,000,000 gallons per acre daily. The maximum loss of head in the case of each filter is about 73 inches.

Filter No. 3 B has been operated intermittently since Sept. 23, 1893, as follows: at 5 A.M. the gate on the outlet pipe, to which no trap has been attached, was closed, and the water turned on at the top, near the edge. When the filter was covered (about 7.30 A.M.) the gate on the outlet pipe was opened to give the prescribed rate of filtration, and the surface was kept covered until 9 P.M., when the water was shut off and the filter allowed to drain during the night. The filter has been operated in this manner six days in a week, and allowed to rest, after draining, on the seventh day. The rate of flow was 10 gallons per minute for about 16 hours during the day. This rate is equivalent to 2,880,000 gallons per acre daily (24 hours). In addition to the quantity of effluent obtained at this rate for 16 hours daily there is the daily drainage of the water held in the pores of the sand, equivalent to about 400,000 gallons per acre. On Feb. 27, 1894, the rate was reduced from 10 to 8 gallons per minute, owing to a lack of water supplied by the inlet pipe. The total

quantity of effluent yielded up to May 1, 1894, was equivalent to 356,191,100 gallons per acre, which is an average daily rate of 1,650,000 gallons per acre, or 1,925,000 gallons for each of the six days weekly on which it was actually operated. The first occasion on which the filter failed to yield water at the prescribed rate was on December 19, when the total quantity of effluent was equivalent to 153,105,500 gallons per acre. The outlet gate was closed, with the surface covered, from 9.25 to 10.25 A.M., during which time the air that had been held in the pores of the sand bubbled up through the surface and caused the water level to drop 5 inches. This treatment was repeated on Dec. 24, 1893, Jan. 13, 15, 16 and 17, 1894. Ice was removed from the surface, in order to facilitate the displacement of air by water within the filter, as follows: January 4, 2 to 8 inches; January 16, 4 inches; February 26, 6 inches. The ice was broken along the edges on January 15, when it was 6 inches thick. The filter was drained every night, and from 1 to 3 inches of frost frequently appeared at the surface and caused an unfavorable effect upon the removal of bacteria and upon nitrification during the winter months (see pages 468 and 481). On Jan. 31, 1894, a wooden conduit, similar to the lateral conduits at the Lawrence city filter, was placed across the middle of the surface to aid in the distribution of the water. The filter was scraped about 0.6 of an inch deep on March 17, 1894, and the surface ridged; the depth of sand at the sides, at right angles to the conduit, was increased 6 inches, and the surface graded off toward the centre, somewhat similar to the arrangement of the surface of the Lawrence city filter. It was not necessary to scrape the surface at this time to relieve clogging, as the loss of head was only 18.5 inches on this date. The total quantity of effluent up to this time was equivalent to 295,226,500 gallons per acre. The discolored and partially clogged sand removed was equal to 0.27 cubic yard per million gallons. The reason that this filter yielded so much more water without scraping than No. 8 A, its continuous mate, was that the method of operation practised caused a disturbance of the accumulating sediment on the surface. The effect of this was also felt in the bacterial results, as will be seen beyond.

In the tables on the pages beyond are presented the daily results obtained from Filters Nos. 3 B and 8 A, and in the foot-notes mention is made of all special features in the operation of the filters.

Filter No. 8 A has been operated continuously since September 26 at the rate of 7 gallons per minute, equivalent to 2,016,000 gal-

lons per acre daily. The rate of filtration, which is controlled by a gate on the outlet pipe to which no trap was attached, was reduced on February 27 to 5 gallons per minute, owing to a reduction in the quantity of water delivered by the inlet pipe. The total quantity of effluent yielded up to May 1, 1894, was equivalent to 359,850,300 gallons per acre, which is an average daily rate of 1,660,000 gallons per acre. During this period the surface was scraped six times, as follows: October 24, November 13, December 2, February 21, March 17 and April 23. The depth removed in each case was about 0.3 of an inch, which is equivalent to 0.70 cubic yard per million gallons on an average. The average quantity of water yielded between scrapings to relieve clogging was 58,200,000 gallons per acre; the minimum, 36,900,000 gallons; and the maximum, 147,-600,000 gallons per acre. The average number of days between scrapings was 35, the minimum 19 and the maximum 81. During the latter period (December 2 to February 21) the filter became clogged seven times, as follows: December 29, January 16, 26 and 29, February 10, 12 and 19. On each occasion the prescribed quantity of water failed to pass through the filter with the gate on the outlet pipe wide open. The pores of the sand at these times contained considerable air; how much of it was evolved by the water is not definitely known, but it appears now that the greater part came through the untrapped outlet pipe, which was only partly filled with water on these days. By shutting the gate on the outlet pipe the air rose to the surface and disturbed the layer of accumulated sediment sufficiently to allow filtration to proceed for some days. To facilitate the displacement of air within the pores by water the ice was removed as follows: December 29, 3 to 8 inches; January 16, 2 to 8.5 inches; January 29, 6 inches; February 12, 3 to 6.5 inches; February 21, 2 to 6 inches. The ice was broken along the edge on February 10 and 19. The space above the top of the sand was 9 inches. It is probable that scraping could have been considerably longer postponed by continuing this method of treatment. The filter was scraped on March 17 for the sake of getting conditions for experiments comparable with those in No. 3 B. The filter was not clogged on that date. Neither filter was at any time protected from the weather.

The monthly averages of the results of chemical and bacterial analyses, which have already been discussed, are presented in the following tables: —

Monthly Averages of Analyses of Merrimack River Water taken from the Canal and applied to Filters Nos. 3 B and 8 A.

[Parts per 100,000.]

Date.	Temperature, Degrees F.			Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Soluble.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
1893.												
September, . .	63	.38	.0108	.0161	-	.22	.0130	.0003	.39	88	-	30,200
October, . . .	57	.34	.0110	.0201	-	[illegible]	[illegible]	.0006	.37	86	-	16,500
November, . .	42	.47	.0071	.0194	-	.19	.0120	.0001	.53	97	-	7,800
December, . .	34	[illegible]	.0067	.0177	-	[illegible]	.0160	[illegible]	.49	96	-	9,800
1894.												
January, . . .	33	.43	.0066	.0164	.0141	.21	.0150	[illegible]	.41	88	1.6	[illegible]
February, . .	34	.40	.0068	.0160	.0148	.22	.0180	.0001	.42	94	1.6	6,000
March, . . .	37	.47	.0040	.0198	.0172	.15	[illegible]	[illegible]	.46	[illegible]	1.0	10,100
April, . . .	47	.43	.0027	.0143	.0125	.16	.0140	.0000	.41	96	1.3	11,500

The bacterial samples in this and in the two following tables correspond as to time of collection to the chemical samples. The results of daily bacterial analyses will be found beyond.

Monthly Averages of Analyses of Effluent of (Intermittent) Filter No. 3 B.

[Parts per 100,000.]

Date.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature, Degrees F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
1893.												
September, .	2,198,800	66	1.35	.0042	.0166	.22	.0170	.0000	[illegible]	-	-	20,000
October, .	1,809,400	56	[illegible]	.0035	.0130	.24	.0190	.0012	.39	97	-	2,700
November, .	1,868,400	41	[illegible]	.0022	.0137	.18	.0220	.0001	.44	100	-	157
December, .	1,718,600	34	[illegible]	.0029	.0121	.20	.0196	.0000	.42	100	-	237
1894.												
January, .	1,602,200	33	.38	.0021	.0117	.21	.0240	.0000	.35	100	1.5	194
February, .	1,464,700	33	.34	.0018	.0107	.22	.0270	.0000	.36	100	1.6	197
March, . .	1,452,600	37	.40	.0014	.0095	.15	[illegible]	.0000	.35	[illegible]	1.0	166
April, . .	1,497,500	48	.35	.0011	.0090	.16	.0200	.0000	.33	99	1.4	83

Monthly Averages of Analyses of Effluent of (Continuous) Filter No. 8 A.

[Parts per 100,000.]

				Ammonia.			Nitrogen as					
			Color.	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
September, .	1,926,200	58	.56	.0014	.0122	.22	.0160	.0000	[illegible]	–	–	10,400
October, .	1,780,500	56	[illegible]	.0053	.0122	.24	.0180	.0008	.26	89	–	1,800
November, .	1,898,500	41	.39	.0018	.0124	.19	[illegible]	[illegible]	.42	94	–	125
December, .	1,966,400	[illegible]	.37	.0021	.0117	.20	.0220	[illegible]	.20	94	–	125
1894.												
January, .	1,683,400	33	.37	.0016	.0115	.21	.0300	.0000	.36	89	1.5	72
February, .	1,465,000	33	.32	[illegible]	.0106	.22	.0310	[illegible]	.33	94	1.6	62
March, . .	1,290,200	30	.39	[illegible]	.0102	.16	.0180	.0000	.34	93	1.0	71
April, . .	1,371,400	[illegible]	[illegible]	.0014	.0067	.15	.0210	.0008	[illegible]	94	1.4	37

Monthly Averages of Bacterial Results from (Intermittent) Filter No. 3 B.

Date.	Total Quantity of Effluent for Month. — Gallons per Acre.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
			8 A.M.	11 A.M.	2 P.M.	4 P.M.
1893.						
October, ...	65,867,000	22,900	–	[illegible]	2,670	–
November, ...	56,052,600	7,900	304	278	173	[illegible]
December, ...	53,275,300	10,200	308	290	236	251
1894.						
January, ...	49,358,000	7,100	208	230	224	206
February, ...	40,731,400	8,200	[illegible]	214	146	171
March, ...	45,960,400	7,700	188	162	121	180
April, ...	44,926,400	12,700	148	134	88	74
Averages, Nov.-April, inclusive, ...		9,000	230	214	166	164
Average per cent. in effluent of number applied,		–	2.56	2.38	1.83	1.73

The treatment of this filter on March 17, 1894, by which the surface was ridged in the manner already described, appeared to lessen the mechanical disturbance of the sand during the process of filling

the filter from the top, and thereby increase its bacterial efficiency. The average of the results given above show that during the period November to April, inclusive, this filter allowed 2.13 per cent. of the number of applied bacteria to pass through into the effluent. These results, however, cover only the first eight hours of each day's flow, and it has been learned that during the latter half of the flow (4 P.M. to midnight) the efficiency is practically the same or a very little greater than at 4 P.M. Averaging then the results obtained at 4 P.M. with the total average for the first half of the day (8 A.M. to 4 P.M.) we find that 1.93 per cent. of the number of applied bacteria passed through, — a removal of 98.07 per cent.

Monthly Averages of Bacterial Results from (Continuous) Filter No. 8 A.

DATE.	Total Quantity of Effluent for Month. — Gallons per Acre.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
			8 A.M.	11 A.M.	2 P.M.	4 P.M.
1893.						
October,	63,200,400	23,000	-	2,540	3,200	-
November,	56,953,600	7,900	124	117	117	110
December,	60,958,800	10,200	92	92	117	142
1894.						
January,	56,835,600	7,100	70	79	80	88
February,	40,765,200	8,200	83	76	73	72
March,	39,995,200	7,700	67	70	67	65
April,	41,141,500	12,700	40	40	41	42
Averages, Nov.-April, inclusive,		9,000	79	79	83	86
Average per cent. in effluent of number applied,		-	0.88	0.88	0.92	0.95

Experiments upon this filter show that, under normal conditions, its efficiency in removing bacteria is substantially the same during the entire twenty-four hours. The averages given above include all results obtained and indicate that in some cases somewhat variable numbers were found in the effluent during the day. This is explained by the existence of some abnormal condition during a very few days in the month. The average results for the period, November to April, inclusive, show that the effluent contained 0.91 per cent. of the number of applied bacteria, — a removal of 99.09 per cent.

Filter No. 3 B (Intermittent).

DATE — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent. 11 A.M.	2 P.M.
September 27,	2,823,200	39,900	12,800	13,900
28,	2,024,200	64,800	20,600	13,000
29,	1,662,400	44,800	36,600	18,600
30,	2,285,600	79,800	33,600	21,600
October 1,	0	-	-	-
2,	2,087,200	24,300	-	6,400
3,	2,200,400	18,600	3,300	1,500
4,	2,188,000	20,200	8,300	4,800
5,	2,145,400	12,500	4,100	2,400
6,	2,259,000	13,800	2,700	1,500
7,	2,120,000	22,000	4,200	-
8,	0	-	-	-
9,	2,205,800	8,600	1,700	900
10,	2,261,000	25,000	3,000	1,260
11,	2,080,000	45,600	6,800	4,600
12,	2,151,600	55,200	2,100	2,000
13,	2,186,800	34,200	5,200	-
14,	2,088,400	51,300	1,870	-
15,	0	-	-	-
16,	2,179,800	22,000	1,200	420
17,	2,242,600	16,200	1,020	640
18,	2,106,800	4,600	450	210
19,	2,292,000	5,200	280	180
20,	2,227,400	6,800	760	120
21,	2,329,000	6,300	270	160
22,	0	-	-	-
23,	2,260,000	1,900	280	160
24,	2,252,000	4,800	230	-
25,	2,037,600	16,200	480	120
26,	2,262,000	20,700	230	130
27,	2,138,200	7,200	540	330
28,	2,235,800	7,100	400	210
29,	0	-	-	-
30,	2,265,400	6,000	210	120
31,	2,289,400	4,400	180	160

The total quantity of effluent to the end of October was equivalent to 65,887,000 gallons per acre.

Filter No. 8 A (Continuous).

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.	
			11 A.M.	2 P.M.
September 27,	1,671,400	39,900	12,100	13,500
28,	2,016,000	64,800	18,700	24,000
29,	1,961,400	44,800	12,000	14,600
30,	2,056,000	79,800	6,900	15,000
October 1,	2,056,000	-	-	-
2,	1,970,000	24,300	3,300	4,400
3,	2,002,000	18,600	3,000	2,800
4,	2,007,400	20,200	2,700	3,300
5,	2,030,000	12,500	2,700	1,600
6,	2,044,000	13,800	3,000	2,200
7,	630,000	22,000	2,600	-
8,	0	-	-	-
9,	1,917,000	8,600	1,040	530
10,	1,894,800	25,000	340	420
11,	2,009,000	45,600	1,750	720
12,	2,002,000	55,200	420	900
13,	1,995,800	34,200	430	-
14,	1,998,500	51,300	190	-
15,	1,998,500	-	-	-
16,	2,184,000	22,000	190	180
17,	1,925,600	16,200	210	200
18,	2,009,000	4,600	120	130
19,	1,927,200	5,200	180	120
20,	1,878,200	6,800	190	220
21,	1,947,200	6,300	260	240
22,	1,000,000	-	-	-
23,	263,400	1,900	220	290
24,	1,673,000	4,800	-	180
25,	2,044,000	16,200	270	320
26,	2,023,000	20,700	130	140
27,	2,009,000	7,200	220	210
28,	2,023,000	7,100	190	190
29,	2,023,000	-	-	-
30,	2,016,000	6,000	90	90
31,	1,995,000	4,100	150	120

The total quantity of effluent to the end of October was 63,200,400 gallons per acre.

The gate on the outlet pipe was closed October 7, 4 P.M., to October 9, 8 A.M.; and October 23, 8.40 to 11.35 A.M. On October 24 the surface was allowed to uncover, and was scraped between 10 and 12 A.M.

Filter No. 3 B (Intermittent) — Continued.

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
			8 A.M.	11 A.M.	2 P.M.	4 P.M.
November 1, . . .	2,293,000	6,000	336	300	164	110
2, . . .	2,185,800	7,600	276	384	137	170
3, . . .	2,251,000	8,000	100	240	198	110
4, . . .	2,186,400	6,300	102	240	144	110
5, . . .	0	-	-	-	-	-
6, . . .	2,225,400	7,300	510	546	250	100
7, . . .	2,102,800	5,200	396	324	150	75
8, . . .	2,200,400	4,400	390	258	98	112
9, . . .	2,269,800	4,600	294	258	150	115
10, . . .	2,197,000	5,600	240	145	140	60
11, . . .	2,072,400	5,100	215	296	162	112
12, . . .	0	-	-	-	-	-
13, . . .	2,252,200	8,700	351	321	100	120
14, . . .	1,978,000	8,900	294	243	170	108
15, . . .	1,986,000	4,700	180	128	57	97
16, . . .	2,217,400	6,900	210	208	120	65
17, . . .	2,101,000	6,300	170	248	114	98
18, . . .	2,270,400	6,700	240	221	105	62
19, . . .	0	-	-	-	-	-
20, . . .	2,145,600	8,900	400	216	120	140
21, . . .	2,071,200	8,200	180	60	150	145
22, . . .	2,185,600	8,200	132	180	117	110
23, . . .	2,110,600	18,300	240	190	105	89
24, . . .	2,105,200	10,100	246	270	252	100
25, . . .	2,170,800	11,500	396	360	300	300
26, . . .	0	-	-	-	-	-
27, . . .	2,259,200	10,500	600	480	140	124
28, . . .	1,992,000	9,100	420	480	629	429
29, . . .	2,095,600	12,300	450	230	260	140
30, . . .	2,127,800	6,800	584	-	-	-

Quantity of effluent for month was 56,052,600 gallons per acre.

Filter No. 8 A (Continuous) — Continued.

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
			8 A.M.	11 A.M.	2 P.M.	4 P.M.
November 1, . . .	2,023,000	6,000	210	56	58	96
2, . . .	1,988,000	7,600	170	123	180	180
3, . . .	2,051,000	8,000	130	150	164	108
4, . . .	2,002,000	6,300	97	75	121	55
5, . . .	2,002,000	-	-	-	-	-
6, . . .	1,985,400	7,300	46	92	95	75
7, . . .	1,955,800	5,200	125	120	120	112
8, . . .	2,027,200	4,400	65	91	62	76
9, . . .	1,829,600	4,600	110	100	114	125
10, . . .	1,685,600	5,600	110	130	184	216
11, . . .	1,000,000	5,100	185	275	279	240
12, . . .	348,400	-	-	-	-	-
13, . . .	1,663,200	8,700	559	342	310	378
14, . . .	2,002,000	8,900	270	240	105	90
15, . . .	2,016,000	4,700	130	123	160	91
16, . . .	2,001,400	6,900	140	127	110	104
17, . . .	2,016,000	6,300	97	70	100	70
18, . . .	2,026,500	6,700	105	107	70	87
19, . . .	2,026,500	-	-	-	-	-
20, . . .	2,084,200	8,900	110	80	95	70
21, . . .	2,169,800	8,200	100	140	102	100
22, . . .	2,051,000	8,200	80	97	92	90
23, . . .	1,961,000	18,300	58	52	89	90
24, . . .	2,037,000	10,100	50	55	35	20
25, . . .	2,030,000	11,500	45	46	44	26
26, . . .	2,000,000	-	-	-	-	-
27, . . .	1,985,200	10,500	26	70	82	54
28, . . .	2,046,800	9,100	76	90	112	120
29, . . .	2,023,000	12,300	78	80	45	88
30, . . .	1,916,000	6,800	75	-	-	-

Quantity of effluent for month was 56,953,600 gallons per acre.

The outlet pipe was closed November 11, 9 to 10 A.M., but no air came out at the surface. The surface was scraped November 13 between 11 A.M. and 3 P.M.

Filter No. 3 B (Intermittent) — Continued.

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
			8 A.M.	11 A.M.	2 P.M.	4 P.M.
December 1, . . .	2,084,800	12,300	408	270	190	167
2, . . .	2,055,000	15,500	790	390	240	250
3, . . .	0	-	-	-	-	-
4, . . .	1,897,800	11,200	558	336	300	240
5, . . .	1,920,800	11,700	318	690	270	218
6, . . .	2,043,800	10,500	288	360	170	165
7, . . .	1,986,200	11,900	230	190	222	185
8, . . .	2,157,800	10,300	192	249	218	294
9, . . .	2,190,600	10,400	252	294	-	-
10, . . .	0	-	-	-	-	-
11, . . .	2,207,800	9,200	360	384	330	318
12, . . .	2,123,000	8,500	275	270	202	252
13, . . .	2,025,600	7,400	370	240	354	270
14, . . .	2,086,600	9,000	130	192	336	318
15, . . .	2,100,700	7,200	151	180	348	204
16, . . .	2,030,600	10,600	270	150	-	-
17, . . .	0	-	-	-	-	-
18, . . .	2,254,800	12,800	270	258	240	720
19, . . .	1,900,200	21,200	300	195	240	270
20, . . .	1,938,400	11,600	288	310	330	420
21, . . .	2,084,600	11,200	180	198	180	240
22, . . .	2,103,000	9,100	329	220	276	288
23, . . .	2,057,000	8,300	386	294	228	170
24, . . .	1,817,600	-	-	-	-	-
25, . . .	0	-	-	-	-	-
26, . . .	2,017,400	10,300	360	360	246	210
27, . . .	2,053,800	5,000	220	147	167	140
28, . . .	2,052,000	5,300	285	261	120	156
29, . . .	2,015,600	5,800	340	330	128	146
30, . . .	2,069,800	7,600	153	227	133	140
31, . . .	0	-	-	-	-	-

Quantity of effluent for month was 53,275,300 gallons per acre.

To remove the air held in the pores of the sand and which prevented a normal flow of water the outlet was closed December 19, 9.25 to 10.25 A.M., and December 24, 9.45 to 11 A.M.

Filter No. 8 A (Continuous) — Continued.

Date — 1893.	Quantity of Effluent. — Gallons per Acre Daily.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
			8 A.M.	11 A.M.	2 P.M.	4 P.M.
December 1, . . .	1,764,200	12,300	57	170	210	147
2, . . .	1,837,500	15,500	354	-	-	843
3, . . .	1,837,500	-	-	-	-	-
4, . . .	1,953,600	11,200	180	170	300	120
5, . . .	2,037,000	11,700	215	184	246	140
6, . . .	2,009,000	10,500	110	140	180	120
7, . . .	1,957,600	11,900	123	105	82	77
8, . . .	2,009,000	10,300	72	86	125	146
9, . . .	1,980,500	10,400	35	70	-	-
10, . . .	1,980,500	-	-	-	-	-
11, . . .	2,916,000	9,200	45	67	70	98
12, . . .	2,016,000	8,500	49	63	60	57
13, . . .	2,080,000	7,400	44	32	43	48
14, . . .	2,090,000	9,000	51	73	68	81
15, . . .	1,920,200	7,200	34	26	30	74
16, . . .	2,182,500	10,600	22	46	-	-
17, . . .	2,132,500	-	-	-	-	-
18, . . .	2,030,000	12,800	110	138	120	147
19, . . .	1,988,000	21,200	98	75	140	110
20, . . .	2,037,000	11,600	114	98	72	120
21, . . .	2,016,000	11,200	41	53	56	59
22, . . .	1,988,000	9,100	79	52	96	80
23, . . .	2,058,000	8,300	99	92	97	-
24, . . .	1,885,700	-	-	-	-	-
25, . . .	1,885,700	-	-	-	-	-
26, . . .	1,994,000	10,300	44	49	49	50
27, . . .	1,829,800	5,000	35	45	50	56
28, . . .	1,796,000	5,300	50	87	79	143
29, . . .	1,715,000	5,800	165	210	302	306
30, . . .	2,016,000	7,600	74	78	92	93
31, . . .	2,016,000	-	-	-	-	-

Quantity of effluent for month was 60,958,800 gallons per acre.

The surface was scraped on December 2 between 10 A.M and 4 P.M. The loss of head was equal to the depth of the filter on December 29; the ice 3 to 8 inches in thickness was removed and the outlet closed 8.30 to 11.45 A.M. to allow the escape of air held in the sand.

Filter No. 3 B (Intermittent) — Continued.

Date — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.)		Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
		8 A.M.	4 P.M.		8 A.M.	11 A.M.	2 P.M.	4 P.M.
January 1, . . .	2,165,000	-	-	4,500	338	204	252	236
2, . . .	1,955,600	-	-	5,000	258	166	170	185
3, . . .	1,593,400	-	-	3,600	152	150	142	108
4, . . .	1,862,200	-	-	4,400	112	211	223	210
5, . . .	1,914,800	-	-	6,000	150	160	146	155
6, . . .	2,090,600	-	-	7,800	305	273	173	112
7, . . .	0	-	-	-	-	-	-	-
8, . . .	2,068,600	58.3	13.3	8,200	235	205	378	522
9, . . .	2,058,600	43.0	17.8	7,500	283	224	310	148
10, . . .	2,222,200	40.0	14.0	6,700	358	277	280	267
11, . . .	2,087,800	14.0	15.0	6,800	276	210	170	140
12, . . .	1,988,800	14.8	15.5	7,600	289	195	197	191
13, . . .	340,000	61.0	-	7,900	-	-	-	119
14, . . .	0	-	-	-	-	-	-	-
15, . . .	1,253,400	-	58.0	10,500	-	-	-	149
16, . . .	1,815,600	72.0	65.0	7,100	-	468	334	348
17, . . .	1,696,200	62.5	57.8	6,800	-	215	348	474
18, . . .	2,087,000	57.5	51.5	8,100	202	210	372	140
19, . . .	2,022,400	16.5	15.0	8,500	206	220	196	189
20, . . .	1,995,000	43.5	14.3	7,300	118	221	330	285
21, . . .	0	-	-	-	-	-	-	-
22, . . .	2,183,800	16.5	14.8	9,700	226	314	156	159
23, . . .	1,950,200	13.5	15.3	8,600	316	269	210	241
24, . . .	1,970,600	15.3	16.0	6,200	124	242	191	110
25, . . .	1,957,600	15.3	16.0	6,300	80	165	186	95
26, . . .	2,168,000	41.0	18.0	6,100	96	145	189	241
27, . . .	2,145,800	13.0	13.5	9,000	92	117	162	123
28, . . .	0	-	-	-	-	-	-	-
29, . . .	1,874,800	14.5	15.0	6,400	115	191	201	167
30, . . .	0	-	-	6,900	-	-	-	-
31, . . .	2,040,000	-	12.3	7,700	-	-	-	170

Quantity of effluent for month was 49,358,000 gallons per acre.

January 4, 2 to 8 inches of ice removed. January 13, outlet closed 10.45 A.M. to 2.50 P.M. January 15, ice 6 inches thick was broken along the edge and outlet closed until 3.50 P.M. January 16, 4 inches of ice removed and outlet closed 10 to 11.15 A.M. January 17, outlet opened at 10.30 A.M.; a large quantity of air appeared at the surface. January 31, a wooden distributing trough put on surface.

Filter No. 8 A (Continuous) — Continued.

Date — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.) 8 A.M.	Loss of Head. (Inches.) 4 P.M.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent. 8 A.M.	11 A.M.	2 P.M.	4 P.M.
January 1, . . .	2,016,000	-	-	4,500	44	39	40	50
2, . . .	2,016,000	-	-	5,000	49	47	52	59
3, . . .	2,072,000	-	-	3,600	59	65	58	51
4, . . .	1,974,000	-	-	4,400	37	48	54	40
5, . . .	2,016,000	-	-	6,000	24	31	58	60
6, . . .	2,016,000	-	-	7,800	24	30	47	58
7, . . .	2,016,000	-	-	-	-	-	-	-
8, . . .	1,945,000	13.5	21.0	8,200	47	42	50	52
9, . . .	2,245,400	16.5	24.5	7,500	36	48	56	33
10, . . .	1,892,400	24.5	28.5	6,700	71	126	98	146
11, . . .	1,895,000	31.0	31.0	6,800	102	110	118	122
12, . . .	2,039,000	48.8	51.5	7,600	148	165	185	184
13, . . .	1,925,000	62.0	60.3	7,900	221	288	243	206
14, . . .	1,925,000	-	-	-	-	-	-	-
15, . . .	1,628,000	69.0	78.0	10,500	200	252	240	208
16, . . .	1,538,000	73.0	12.5	7,100	105	-	158	158
17, . . .	2,002,000	11.5	11.8	6,800	189	98	106	125
18, . . .	2,037,000	12.0	12.0	8,100	89	77	78	92
19, . . .	2,023,000	13.0	12.8	8,500	38	86	52	75
20, . . .	2,019,500	14.5	15.0	7,300	45	57	43	37
21, . . .	2,019,500	-	-	-	-	-	-	-
22, . . .	1,886,200	19.0	20.5	9,700	23	25	32	76
23, . . .	2,030,000	23.5	24.5	8,600	45	48	51	81
24, . . .	1,865,800	27.3	32.3	6,200	83	61	44	41
25, . . .	1,704,600	47.0	57.5	6,300	42	27	65	68
26, . . .	219,000	73.0	47.0	6,100	60	58	69	-
27, . . .	1,841,200	37.0	62.0	9,000	49	58	51	111
28, . . .	400,000	-	-	-	-	-	-	-
29, . . .	1,607,000	73.0	10.5	6,400	23	-	-	64
30, . . .	2,044,000	18.5	13.5	6,900	30	53	56	53
31, . . .	1,988,000	10.3	10.3	7,700	46	41	46	46

Quantity of effluent for month, 56,835,600 gallons per acre.

January 16, 2 to 3.5 inches ice removed, and outlet closed 8 A.M. to 1.50 P.M. to allow escape of air. January 26, outlet closed 9.10 to 11.10 A.M., and from 2 P.M. to 8.35 A.M. January 27. January 29, 6 inches ice removed and outlet closed 9 A.M. to 3.20 P.M.

Filter No. 3 B (Intermittent) — Continued.

Date — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.) 8 A.M.	Loss of Head. (Inches.) 4 P.M.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent. 8 A.M.	11 A.M.	2 P.M.	4 P.M.
February 1, . . .	2,152,400	12.0	11.5	7,900	151	146	114	105
2, . . .	2,021,800	15.5	14.0	7,300	255	278	131	114
3, . . .	2,019,000	14.0	14.0	4,100	204	340	102	185
4, . . .	0	-	-	-	-	-	-	-
5, . . .	1,881,600	11.3	13.0	9,900	288	270	203	184
6, . . .	1,718,400	15.5	13.8	8,900	-	258	190	170
7, . . .	1,935,600	15.0	15.3	10,700	208	190	121	135
8, . . .	2,098,600	15.0	14.8	7,800	323	198	123	-
9, . . .	2,056,600	13.5	16.0	9,500	247	246	190	107
10, . . .	2,166,600	14.0	15.0	9,300	306	280	116	128
11, . . .	0	-	-	-	-	-	-	-
12, . . .	1,986,200	35.3	15.8	12,400	255	178	216	437
13, . . .	1,830,800	10.0	31.8	6,000	-	225	170	226
14, . . .	1,729,400	14.5	14.0	6,100	332	258	149	197
15, . . .	1,747,400	13.0	14.5	7,500	271	218	125	138
16, . . .	1,314,200	14.5	8.3	9,100	265	219	165	182
17, . . .	1,503,000	11.0	8.3	7,300	212	127	135	120
18, . . .	0	-	-	-	-	-	-	-
19, . . .	2,086,400	15.8	16.0	10,100	205	180	158	140
20, . . .	1,504,000	15.0	16.0	8,400	240	218	108	132
21, . . .	1,646,200	15.0	15.8	8,700	-	257	192	120
22, . . .	1,962,000	19.8	17.3	8,600	153	160	185	189
23, . . .	1,734,600	13.3	15.3	6,800	227	222	145	-
24, . . .	10,000	-	-	6,700	-	-	-	372
25, . . .	458,800	-	-	-	-	-	-	-
26, . . .	0	-	-	9,500	-	-	-	-
27, . . .	1,544,400	10.0	9.3	8,300	100	60	55	50
28, . . .	1,623,400	12.0	12.3	6,400	120	180	120	150

Quantity of effluent for month was 40,731,400 gallons per acre.

February 1, the filter was not drained on the night preceding. February 24, the filter was filled from below with city filtered water. February 26, 6 inches of ice removed; 1 to 2.5 inches of frost in sand; filled with city-filtered water from below (rate, 1,150,000 gallons per acre daily) and allowed to stand over night. February 27, rate reduced from 10 to 8 gallons per minute.

Filter No. 8 A (Continuous) — Continued.

Date — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.)		Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
		8 A.M.	4 P.M.		8 A.M.	11 A.M.	2 P.M.	4 P.M.
February 1, . . .	2,016,000	9.0	9.5	7,900	42	28	32	62
2, . . .	2,016,000	10.5	12.0	7,300	45	45	37	66
3, . . .	2,016,000	14.0	15.0	4,100	52	69	40	59
4, . . .	2,016,000	-	-	-	-	-	-	-
5, . . .	2,009,000	21.0	22.8	9,900	71	69	60	67
6, . . .	1,722,000	11.5	17.8	8,900	58	50	40	38
7, . . .	2,016,000	20.8	24.0	10,700	48	60	46	60
8, . . .	2,016,000	27.8	33.5	7,800	31	39	39	34
9, . . .	1,704,400	48.3	59.0	9,500	23	24	27	24
10, . . .	1,328,200	73.0	40.0	9,800	102	-	-	29
11, . . .	1,328,200	-	-	-	-	-	-	-
12, . . .	1,519,000	73.0	13.0	12,400	228	-	152	119
13, . . .	2,058,009	12.5	18.0	6,000	110	104	91	115
14, . . .	2,009,000	13.0	13.5	6,100	92	103	106	76
15, . . .	1,728,000	14.8	16.0	7,500	83	66	86	119
16, . . .	1,945,400	22.0	25.0	9,100	61	80	104	108
17, . . .	1,000,000	31.5	37.0	7,300	95	94	114	116
18, . . .	290,000	-	-	-	-	-	-	-
19, . . .	0	73.0	-	10,100	98	-	-	-
20, . . .	1,843,000	19.0	36.0	8,400	49	80	95	99
21, . . .	151,200	61.0	-	8,700	221	-	-	-
22, . . .	2,009,000	11.3	10.3	8,600	136	167	117	88
23, . . .	2,016,000	11.0	11.0	6,800	91	97	75	60
24, . . .	763,000	8.5	9.0	6,700	98	98	94	97
25, . . .	458,800	-	-	-	-	-	-	-
26, . . .	0	-	-	9,500	-	-	-	-
27, . . .	1,347,000	10.0	6.0	8,300	37	58	114	38
28, . . .	1,440,000	6.5	6.5	6,400	48	45	60	51

Quantity of effluent for month was 40,765,200 gallons per acre.

February 6, inlet pipe frozen and surface uncovered. February 10, ice 4 inches thick broken along the sides and outlet closed 7.55 A.M. to 3.45 P.M. February 12, ice 3 to 6.5 inches thick removed and outlet closed 8 A.M. to 1.40 P.M. February 19, ice 4 inches thick broken along the sides and outlet closed 8.30 A.M. to February 20, 8 A.M. February 21, 2 to 6 inches ice removed and surface scraped. After filling, filter was allowed to stand with outlet closed from 9 P.M. till 8 A.M. the next morning. February 24, inlet pipe frozen and surface uncovered. February 15, filter allowed to drain. February 26, filled with city filtered water from below and allowed to stand over night with outlet closed. February 27, rate reduced from 7 to 5 gallons per minute.

Filter No. 3 B (Intermittent) — Continued.

Date — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.)		Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
		8 A.M.	4 P.M.		8 A.M.	11 A.M.	2 P.M.	4 P.M.
March 1, . . .	1,828,200	11.5	13.0	7,300	135	174	128	130
2, . . .	1,766,200	12.5	12.5	9,800	114	191	178	116
3, . . .	1,798,600	10.0	11.8	6,900	239	119	91	133
4, . . .	0	-	-	-	-	-	-	-
5, . . .	2,272,000	13.5	12.5	7,000	34	52	82	51
6, . . .	1,787,600	13.3	12.0	11,800	107	101	87	77
7, . . .	1,747,400	9.5	11.8	13,600	360	190	115	159
8, . . .	1,806,600	12.5	12.5	18,400	256	252	152	190
9, . . .	1,798,600	12.0	14.0	13,000	281	340	245	141
10, . . .	1,569,200	12.0	13.8	12,800	337	290	156	159
11, . . .	0	-	-	-	-	-	-	-
12, . . .	1,933,000	13.5	14.8	10,900	80	56	84	132
13, . . .	1,809,800	13.0	13.5	9,800	285	221	217	102
14, . . .	1,827,400	10.5	13.8	8,600	257	196	136	61
15, . . .	1,726,600	11.0	14.0	7,800	220	190	183	130
16, . . .	1,836,000	10.5	13.3	6,300	167	161	117	96
17, . . .	400,000	18.5	-	6,000	150	-	-	-
18, . . .	0	-	-	-	-	-	-	-
19, . . .	1,736,200	10.0	9.0	5,200	29	41	63	80
20, . . .	1,704,000	10.5	10.3	4,100	144	190	114	80
21, . . .	1,656,400	9.5	11.5	3,900	130	136	80	112
22, . . .	1,779,200	11.0	11.5	4,000	-	107	87	76
23, . . .	1,598,400	9.5	13.5	4,900	140	110	42	108
24, . . .	1,625,600	10.8	11.5	3,600	160	153	90	50
25, . . .	0	-	-	-	-	-	-	-
26, . . .	1,767,200	11.5	12.0	4,900	78	81	89	95
27, . . .	1,376,000	-	-	3,500	230	196	98	122
28, . . .	1,888,000	10.8	11.8	2,100	206	155	95	75
29, . . .	1,649,600	13.0	14.0	3,600	157	114	75	56
30, . . .	1,617,600	12.3	12.3	8,600	308	152	126	175
31, . . .	1,640,000	11.0	11.5	10,200	290	242	210	142

Quantity of effluent for month was 45,960,400 gallons per acre.

March 4 and 11, filter filled with city filtered water from below and allowed to stand over night. March 17, surface scraped and new sand added to ridge the surface similar to that of the Lawrence city filter; the sand at the sides at right angles to the wooden conduit was made 6 inches deeper than in the middle, towards which it was graded. The filter was filled from below with city filtered water on the night of March 18. The filter was filled as usual, from the top, on March 25, and allowed to stand over night with the outlet closed.

Filter No. 8 A (Continuous) — Continued.

DATE — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.) 8 A.M.	Loss of Head. (Inches.) 4 P.M.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent. 8 A.M.	11 A.M.	2 P.M.	4 P.M.
March 1, . . .	1,445,000	6.5	6.5	7,300	28	58	40	42
2, . . .	1,440,000	6.5	6.5	9,800	33	81	56	61
3, . . .	1,380,000	6.5	6.5	6,900	51	42	56	58
4, . . .	500,000	-	-	-	-	-	-	-
5, . . .	1,270,000	7.5	7.3	7,000	-	74	49	26
6, . . .	1,440,000	8.0	7.3	11,800	55	85	74	70
7, . . .	1,445,000	7.3	6.5	13,600	74	66	80	63
8, . . .	1,445,000	7.0	7.0	18,400	73	75	70	78
9, . . .	1,425,000	7.0	6.5	13,000	87	110	63	97
10, . . .	1,396,000	6.5	6.5	12,800	98	87	64	95
11, . . .	664,600	-	-	-	-	-	-	-
12, . . .	1,240,000	7.5	7.8	10,900	-	68	44	55
13, . . .	1,440,000	8.0	7.5	9,800	97	86	91	62
14, . . .	1,440,000	7.8	7.8	8,600	80	87	95	98
15, . . .	1,440,000	8.8	8.5	7,800	73	77	79	78
16, . . .	1,440,000	8.5	8.0	6,300	87	63	76	67
17, . . .	664,800	8.0	-	6,000	50	-	-	-
18, . . .	0	-	-	-	-	-	-	-
19, . . .	1,245,000	7.3	7.0	5,200	-	64	50	49
20, . . .	1,395,000	7.8	7.8	4,100	102	96	106	93
21, . . .	1,440,000	7.5	7.5	3,900	75	40	92	65
22, . . .	1,440,000	6.5	6.5	4,000	70	78	56	74
23, . . .	1,440,000	6.5	6.5	4,900	86	78	81	60
24, . . .	1,447,500	6.5	6.5	3,600	55	63	61	61
25, . . .	1,447,500	-	-	-	-	-	-	-
26, . . .	1,455,000	7.0	6.3	4,900	50	46	49	41
27, . . .	1,410,000	-	-	3,500	56	54	55	54
28, . . .	1,440,000	6.5	6.5	2,100	24	26	19	20
29, . . .	1,440,000	6.5	6.5	3,600	32	34	41	36
30, . . .	1,440,000	7.5	8.5	8,600	78	88	98	90
31, . . .	1,440,000	8.0	8.0	10,200	95	106	100	115

Quantity of effluent for month was 39,995,200 gallons per acre.

The filter was allowed to drain March 4, 11 and 17; and was filled with city filtered water from below March 5, 12 and 19, and put in operation in the usual manner as soon as the surface was covered. The surface was scraped on March 17.

Filter No. 3 B (Intermittent) — Concluded.

Date — 1894.	Quantity of Effluent. Gallons per Acre Daily.	Loss of Head. (Inches.)		Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent.			
		8 A.M.	4 P.M.		8 A.M.	11 A.M.	2 P.M.	4 P.M.
April 1, . . .	0	-	-	-	-	-	-	-
2, . . .	1,771,200	11.0	11.3	9,400	183	142	65	74
3, . . .	1,635,000	11.8	11.8	5,600	225	338	172	118
4, . . .	1,596,600	11.5	12.0	16,900	300	270	190	31
5, . . .	1,827,400	10.5	12.3	13,600	128	143	37	76
6, . . .	1,708,800	12.0	12.3	9,400	185	142	71	70
7, . . .	1,688,000	11.0	11.8	12,800	245	206	95	104
8, . . .	0	-	-	-	-	-	-	-
9, . . .	1,793,600	10.3	11.8	14,700	112	107	90	84
10, . . .	1,643,200	11.8	13.0	14,500	249	203	108	114
11, . . .	1,672,000	13.0	13.8	13,800	159	150	112	108
12, . . .	1,684,800	11.0	14.0	20,700	127	136	112	71
13, . . .	1,606,000	13.0	14.3	20,600	95	173	92	70
14, . . .	1,657,600	10.3	15.0	19,500	135	120	102	88
15, . . .	0	-	-	-	-	-	-	-
16, . . .	1,763,000	9.8	11.3	20,000	80	60	47	82
17, . . .	1,694,800	10.0	11.8	8,800	110	75	65	38
18, . . .	1,697,600	11.0	12.5	11,600	66	54	28	35
19, . . .	1,652,800	12.0	12.8	12,000	108	101	83	72
20, . . .	1,700,200	11.0	12.0	15,100	92	88	86	69
21, . . .	1,723,600	11.0	12.5	28,200	114	76	82	97
22, . . .	0	-	-	-	-	-	-	-
23, . . .	848,000	11.0	11.8	9,800	235	140	66	97
24, . . .	1,795,200	10.5	12.0	4,400	90	110	98	96
25, . . .	1,529,600	12.5	14.0	14,000	174	160	103	68
26, . . .	832,000	15.8	15.5	6,700	140	112	110	47
27, . . .	1,793,600	11.0	12.0	5,500	160	82	70	40
28, . . .	1,763,000	12.3	14.0	5,400	124	59	45	39
29, . . .	0	-	-	-	-	-	-	-
30, . . .	1,758,800	10.3	11.5	3,700	178	100	72	76

Quantity of effluent for month was 40,926,400 gallons per acre.

The filter was filled from the top in the usual way on April 1, 8, 15, 22 and 29, and allowed to stand over night with the outlet closed. The outlet was closed and the surface remained covered on the night of April 23.

Filter No. 8 A (Continuous) — Concluded.

Date — 1894.	Quantity of Effluent. — Gallons per Acre Daily.	Loss of Head. (Inches.) 8 A.M.	4 P.M.	Bacteria per Cubic Centimeter in Applied Water.	Bacteria per Cubic Centimeter in Effluent. 8 A.M.	11 A.M.	2 P.M.	4 P.M.
April 1, ...	1,440,000	-	-	-	-	-	-	-
2, ...	1,440,000	7.8	9.0	9,400	79	92	58	96
3, ...	1,440,000	7.3	8.0	5,600	54	42	83	58
4, ...	1,440,000	7.8	8.5	16,900	40	58	58	74
5, ...	1,440,000	8.5	9.5	13,600	46	43	46	41
6, ...	1,440,000	7.8	8.3	9,400	41	46	38	44
7, ...	1,440,000	8.3	9.0	12,800	38	39	48	54
8, ...	1,440,000	-	-	-	-	-	-	-
9, ...	1,440,000	10.5	11.3	14,700	38	35	41	38
10, ...	1,440,000	11.5	11.5	14,500	38	50	33	40
11, ...	1,440,000	12.5	13.0	13,800	33	31	27	26
12, ...	1,440,000	14.0	14.0	20,700	17	24	30	24
13, ...	1,440,000	14.5	14.8	20,600	39	32	24	30
14, ...	1,440,000	16.0	14.3	19,500	37	40	45	25
15, ...	1,440,000	-	-	-	-	-	-	-
16, ...	1,440,000	16.3	16.5	20,000	39	30	49	40
17, ...	1,440,000	16.0	17.0	8,300	35	28	28	30
18, ...	1,440,000	17.5	19.5	11,600	18	21	18	24
19, ...	1,440,000	22.0	27.3	12,000	30	32	28	28
20, ...	1,343,200	34.3	41.0	15,100	23	29	29	31
21, ...	1,579,100	49.0	59.0	23,200	27	21	28	28
22, ...	500,000	-	-	-	-	-	-	29
23, ...	279,200	-	-	9,800	26	-	-	-
24, ...	1,440,000	6.0	5.0	4,400	51	62	52	40
25, ...	1,440,000	5.0	5.0	14,000	60	43	56	59
26, ...	1,440,000	5.0	5.0	6,700	47	36	31	38
27, ...	1,440,000	5.0	5.0	5,500	53	43	25	49
28, ...	1,440,000	5.0	5.0	5,400	50	47	54	53
29, ...	1,440,000	-	-	-	-	-	-	-
30, ...	1,440,000	4.5	4.5	3,700	41	42	57	61

Quantity of effluent for month was 41,141,500 gallons per acre.
The surface was scraped on April 23.

Lawrence City Filter.

This filter was first put in use Sept. 20, 1893. The construction and operation of the filter are fully described in an article beyond by its designer, Mr. Hiram F. Mills, A.M., C.E., chairman of the committee on water supply and sewerage of the State Board of Health. Briefly, it is 2.5 acres in area; the underdrains conduct the effluent to a collecting conduit and thence to the pump well. The nominal capacity of the pumps is 5,000,000 gallons in 24 hours, and when pumping at this rate water passes through the filter at a rate of 2,000,000 gallons per acre in 24 hours. The average daily consumption is a little over 3,000,000 gallons, and the pumps work on an average about 16 hours; under ordinary circumstances, the surface of the filter is uncovered and the sand drained about 8 hours daily. The effluent is pumped to the open distributing reservoir, which is 25 feet deep at the high-water mark and has a capacity of 40,000,000 gallons.

Very frequent analyses, both chemical and bacterial, have been made of the Merrimack River water before and after its passage through the filter, as it leaves the reservoir, and from taps at the City Hall and Experiment Station, which are distant about 1.5 and 2.5 miles, respectively, from the reservoir. A summary of the results of these analyses is presented below.

Monthly Averages of the Analyses of the Merrimack River Water as it flows on to the Lawrence City Filter.

[Parts per 100,000.]

Month.	Temperature. Degrees F.	Color.	Ammonia.	Ammonia. Albuminoid.		Chlorine.	Nitrogen as		Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
			Free.	Total.	Soluble.		Nitrates.	Nitrites.				
1893.												
September, . .	65	.36	.0113	.0168	-	.22	.0120	.0003	.42	80	-	57,500
October, . . .	57	.27	.0113	.0206	-	.25	.0120	.0004	.28	86	-	22,300
November, . .	42	.45	.0099	.0212	-	.19	.0170	.0006	.47	93	-	10,600
December, . .	34	.44	.0056	.0181	.0150	.20	.0140	.0001	.50	97	-	8,100
1894.												
January, . . .	32	.43	.0075	.0186	.0137	.20	.0140	.0001	.43	88	1.5	7,700
February, . .	32	.39	.0067	.0182	.0162	.21	.0190	.0001	.43	93	1.6	7,600
March, . . .	37	.48	.0026	.0168	.0143	.13	.0110	.0000	.45	100	1.0	6,500
April, . . .	-	.42	.0029	.0157	.0147	.15	.0110	.0000	.40	95	1.3	11,200

For additional analyses and notes with regard to turbidity and odor see page 183.

Monthly Averages of Analyses of Effluent from the City Filter.

[Parts per 100,000.]

Month.	Quantity of Effluent. — Gallons per Acre Daily.	Temperature. Degrees F.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.*
				Free.	Albuminoid.			Nitrates.	Nitrites.			
					Total.	Soluble.						
1893.												
September, .	1,389,900	66	.28	.0072	.0108	-	.23	.0200	.0023	.22	-	6,850
October, .	1,129,800	58	.25	.0079	.0113	-	.25	.0350	.0008	.19	-	1,216
November, .	1,105,200	42	.37	.0102	.0108	-	.22	.0340	.0004	.33	-	161
December, .	1,166,300	35	.36	.0077	.0118	.0112	.20	.0410	.0003	.34	-	111
1894.												
January, .	1,227,600	34	.34	.0071	.0106	.0102	.20	.0370	.0002	.31	3.0	129
February, .	1,218,300	35	.34	.0090	.0099	.0095	.21	.0460	.0001	.29	2.9	244
March, .	1,137,200	39	.40	.0121	.0098	.0085	.18	.0450	.0003	.26	3.3	455
April, . .	996,100	-	.38	.0073	.0097	.0093	.21	.0370	.0000	.31	2.7	281

* The bacterial samples in this set of tables correspond as to time of collection to the chemical samples. The results of daily bacterial analyses are given in the tables beyond.

Monthly Averages of Analyses of Water from the Outlet of the Distributing Reservoir.

[Parts per 100,000.]

Month.	Temperature. Degrees F.	Color.	Ammonia.			Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
			Free.	Albuminoid.			Nitrates.	Nitrites.			
				Total.	Soluble.						
1893.											
September, . .	65	.32	.0077	.0139	-	.22	.0180	.0006	.26	-	556
October, . .	59	.26	.0031	.0144	-	.25	.0250	.0004	.21	-	178
November, . .	44	.33	.0034	.0126	-	.22	.0250	.0000	.32	-	94
December, . .	36	.35	.0055	.0123	.0115	.20	.0300	.0001	.35	-	142
1894.											
January, . .	35	.35	.0054	.0115	.0104	.20	.0320	.0000	.33	2.7	83
February, . .	34	.34	.0055	.0104	.0101	.21	.0410	.0000	.30	2.7	138
March, . . .	38	.36	.0050	.0097	.0092	.20	.0250	.0000	.27	2.5	179
April, . . .	-	.35	.0032	.0093	.0088	.19	.0200	.0000	.27	2.6	137

Monthly Averages of Analyses of Water from a Tap at the Lawrence City Hall.

[Parts per 100,000.]

Month.	Temperature. Degrees F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Bacteria per Cubic Centimeter.
1893.										
September,	64	.30	.0035	.0149	.22	.0290	.0003	.25	-	312
October,	59	.26	.0025	.0135	.24	.0290	.0001	.20	-	152
November,	51	.31	.0032	.0120	.22	.0290	.0000	.29	-	60
December,	42	.34	.0039	.0103	.20	.0300	.0001	.34	-	85
1894.										
January,	38	.35	.0066	.0117	.20	.0360	.0000	.32	2.7	51
February,	38	.33	.0043	.0106	.21	.0400	.0000	.30	2.9	102
March,	39	.36	.0048	.0107	.19	.0300	.0000	.27	2.5	92
April,	-	.33	.0031	.0101	.19	.0300	.0000	.27	2.4	100

Monthly Averages of Analyses of Water from a Tap at the Lawrence Experiment Station.

[Parts per 100,000.]

Month.	Temperature. Degrees F.	Color.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Per Cent. of Dissolved Oxygen.	Hardness.	Bacteria per Cubic Centimeter.
1893.											
September,	63	.26	.0016	.0136	.22	.0300	.0002	.23	64	-	212
October,	59	.24	.0021	.0121	.24	.0270	.0000	.20	79	-	140
November,	51	.30	.0020	.0108	.22	.0310	.0000	.29	89	-	77
December,	42	.34	.0026	.0105	.20	.0340	.0000	.34	94	-	78
1894.											
January,	39	.35	.0027	.0100	.20	.0370	.0000	.32	95	2.5	50
February,	38	.32	.0036	.0098	.21	.0410	.0000	.31	83	2.9	84
March,	39	.34	.0033	.0095	.23	.0430	.0000	.27	80	2.5	150
April,	45	.33	.0023	.0096	.19	.0340	.0000	.27	87	2.4	80

Monthly Averages of Daily Bacterial Results from the Lawrence City Water.

Month.	Bacteria per Cubic Centimeter in Water from River.	Effluent at Filter.	Reservoir Outlet.	City Hall Tap.	Experiment Station Tap.
1893.					
October,	20,900	558	146	127	136
November,	7,500	245	117	68	71
December,	9,800	200	152	92	72
1894.					
January,	7,300	140	80	56	63
February,	8,200	250	130	88	63
March,	8,000	222	220	115	94
April,	14,700	232	127	80	78
Averages,	10,900	264	139	90	82
Average per cent. of number removed,	-	97.58	98.73	99.17	99.25
Average per cent. of number of river bacteria remaining in water,	-	2.42	1.27	0.83	0.75

In the table above all results are included in the averages. Some of these results were obtained under abnormal conditions, and in the table below are presented averages from which are excluded the results from October 1 to 17, which were obtained before the filter arrived at its normal efficiency; those of November 27, 28 and December 4, when high numbers were present in the effluent, which were doubtless caused by lowering the suction pipe in the pump well and thereby disturbing the sediment which had collected there before the filter was put in use; and the results from February 20 to March 12 when the water passed through a very limited area of the filter.

Monthly Averages of Bacterial Results showing the Normal Efficiency of the Lawrence City Filter.

Month.	Bacteria per Cubic Centimeter in Water from River.	Effluent at Filter.	Per Cent. of Number of River Bacteria which appeared in the Effluent.
1893.			
October,	8,700	130	1.50
November,	7,200	177	2.46
December,	9,700	141	1.45
1894.			
January,	7,300	140	1.92
February,	8,000	125	1.56
March,	7,100	100	1.41
April,	14,700	232	1.58
Averages,	9,000	150	1.67

These results show that during this period the normal efficiency of this filter in the removal of bacteria was 98.33 per cent. of the number applied.

In the next table are given the results of the bacterial examination of series of samples of the effluent of the city filter taken at different hours during the day. The pumps were started between 7 and 7.30 A.M. All things taken into consideration, the results are quite uniform under ordinary circumstances. Both the bacterial and the chemical analyses indicate that some ground water at times is mixed with the effluent.

Table showing the Number of Bacteria per Cubic Centimeter at Different Hours in the Effluent of the Lawrence City Filter.

Date—1894.	Bacteria in River Water.	Bacteria in Effluent.										
		7 A.M.	7.30 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	12 M.	1 P.M.	2 P.M.	3 P.M.	4 P.M.
Jan. 8,	8,700	118	148	92	102	85	125	135	188	184	140	Lost.
Jan. 15,	9,300	-	81	106	74	108	108	210	166	140	132	104
Jan. 16,	7,500	103	102	128	190	245	244	280	249	231	191	162
Jan. 29,	8,700	-	85	72	72	109	118	133	168	147	111	97
Feb. 5,	7,800	163	75	75	88	117	107	148	188	178	184	217
Feb. 12,	11,900	-	149	114	63	77	99	135	130	136	175	144
Feb. 19,	11,000	129	105	161	148	139	138	578*	448	409	424	454
Feb. 26,	9,300	764	652	688	640	778	685	648	546	479	-	344
March 12,	9,200	352	334	-	356	885	890	833	832	750	740	913
March 19,	4,400	97	Lost.	-	94	92	94	87	89	93	90	93
March 26,	4,500	-	86	97	88	86	73	92	88	Lost.	92	84
April 2,	11,800	-	-	-	636	251	272	219	221	205	152	180
April 9,	21,400	-	326	185	164	188	212	200	184	190	183	173
April 16,	21,700	280	64	110	75	135	89	100	82	105	90	240
April 23,	13,000	178	115	145	231	194	157	173	-	181	151	180
April 30,	5,900	-	116	91	75	94	89	108	-	80	75	-

* Began to scrape.

The following table shows the number of bacteria in the river water before and after its passage through the filter during the first ten days of its use: —

Date—1893.	Bacteria per Cubic Centimeter.	
	River Water.	Effluent of City Filter.
September 20,	3,200	3,600
22,	20,300	13,500
23,	19,000	15,700
25,	17,000	3,500
26,	6,400	3,600
27,	22,000	5,600
28,	44,300	4,100
29,	93,000	2,600
30,	108,000	3,600

Daily Bacterial Results, Lawrence City Water.

[Bacteria per cubic centimeter.]

Date — 1893.	In River Water.	In Filtered Water from			
		Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.
October 1,	-	-	-	-	-
2,	34,800	700	370	290	250
3,	36,000	1,500	408	240	330
4,	22,200	2,200	252	318	306
5,	16,500	1,000	235	145	276
6,	10,300	240	156	120	110
7,	33,000	300	143	134	98
8,	-	-	-	-	-
9,	9,500	726	162	150	122
10,	24,000	960	108	119	65
11,	48,800	1,920	115	108	101
12,	55,200	880	128	122	110
13,	44,400	448	145	129	85
14,	60,000	265	120	100	110
15,	-	-	-	-	-
16,	-	-	-	-	102
17,	12,500	810	112	126	121
18,	10,500	228	100	100	146
19,	9,200	110	105	80	97
20,	5,500	180	102	80	80
21,	6,200	82	70	92	90
22,	-	-	-	-	-
23,	2,500	126	97	68	117
24,	4,800	100	77	89	130
25,	23,000	131	110	100	180
26,	18,000	160	112	98	104
27,	5,000	110	90	76	122
28,	6,100	65	126	90	100
29,	-	-	-	-	-
30,	-	-	-	-	95
31,	4,900	143	84	76	85

Total quantity of effluent for month, 87,556,523 gallons.

The surface was scraped about ¼ inch deep as follows: the 2 lower beds, October 14; the next 4, October 21; the next 17, October 28; and the remaining 5, October 31.

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

DATE — 1893.	In River Water.	In Filtered Water from			
		Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.
November 1,	6,000	83	60	41	80
2,	3,500	180	110	90	80
3,	4,300	204	120	80	115
4,	6,800	130	83	40	90
5,	-	-	-	-	-
6,	4,700	135	135	95	94
7,	6,500	90	145	50	58
8,	4,400	-	83	60	52
9,	4,600	-	-	-	47
10,	5,600	-	-	-	53
11,	6,000	182	90	61	62
12,	-	-	-	-	-
13,	6,000	90	135	65	50
14,	8,900	-	180	50	62
15,	4,700	-	-	-	35
16,	6,900	-	-	-	68
17,	5,000	240	110	62	33
18,	6,400	194	80	46	64
19,	-	-	-	-	-
20,	12,500	270	112	100	65
21,	8,200	-	150	43	50
22,	8,200	-	-	-	90
23,	15,600	310	86	75	100
24,	9,500	240	100	60	64
25,	9,800	140	58	70	71
26,	-	-	-	-	-
27,	9,800	1,008	176	70	98
28,	13,500	420	210	130	93
29,	12,300	-	-	-	90
30,	6,800	-	-	-	100

Total quantity of effluent for month, 82,887,335 gallons.
Gate on inlet pipe fixed November 15 and 16.
Suction pipe in pump-well lowered November 27.
The second scraping of the surface, about ½ inch deep, was completed November 29 and 30.

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1893.	In River Water.	In Filtered Water from			
		Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.
December 1,	12,300	-	-	100	82
2,	15,500	-	-	73	70
3,	-	-	-	-	-
4,	13,000	840	268	180	78
5,	11,700	-	-	128	73
6,	11,000	240	190	140	61
7,	11,900	125	-	110	88
8,	11,100	100	165	70	76
9,	10,400	-	-	76	68
10,	-	-	-	-	-
11,	9,400	208	-	90	68
12,	8,500	-	-	84	73
13,	9,600	224	-	128	72
14,	9,000	-	-	80	73
15,	7,400	158	126	110	62
16,	10,200	120	-	90	73
17,	-	-	-	-	-
18,	12,800	-	-	80	70
19,	8,900	102	65	68	112
20,	11,600	-	-	60	50
21,	8,000	87	-	74	56
22,	9,100	-	-	68	60
23,	8,300	-	-	83	51
24,	-	-	-	-	-
25,	-	-	-	-	-
26,	10,300	-	-	85	74
27,	6,800	112	117	78	86
28,	5,300	-	-	74	57
29,	5,800	76	135	74	87
30,	7,600	-	-	99	73
31,	-	-	-	-	-

Total quantity of effluent for month, 90,392,937 gallons.

The surface remained covered after the last scraping until about December 16, after which the sand was drained daily when the temperature was 24° F. or above.

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1894.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head.
		Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		Feet.
January 1,	4,500	-	-	-	80	Covered.	-
2,	5,900	75	123	53	96	Drained.	-
3,	3,600	-	98	60	52	"	-
4,	7,500	75	72	53	51	"	-
5,	6,000	-	78	50	76	"	-
6,	5,500	195	-	55	94	Covered.	-
7,	-	-	-	-	-	"	-
8,	8,700	122	98	45	77	"	-
9,	6,600	88	104	77	83	"	-
10,	7,100	80	114	56	61	"	-
11,	6,800	-	94	46	60	"	-
12,	7,400	115	73	39	94	Drained.	-
13,	8,200	137	82	72	73	Covered.	3.1
14,	-	-	-	-	-	"	-
15,	9,300	102	90	71	84	"	2.9
16,	7,600	193	94	60	82	Drained.	3.8
17,	7,700	141	96	51	57	Covered.	3.7
18,	7,400	260	98	71	63	Drained.	3.0
19,	10,500	183	77	65	62	"	3.7
20,	6,100	152	73	70	58	"	3.5
21,	-	-	-	-	-	Covered.	-
22,	7,500	158	51	68	45	"	2.9
23,	8,600	162	56	60	77	Drained.	3.5
24,	5,900	145	34	44	33	"	3.8
25,	8,600	102	52	25	40	"	2.0
26,	6,300	117	50	31	30	Covered.	3.2
27,	6,900	131	74	40	42	"	2.8
28,	-	-	-	-	-	"	-
29,	9,600	112	55	52	54	"	3.0
30,	7,000	137	78	62	34	Drained.	3.0
31,	9,800	208	74	65	38	"	3.1

Total quantity of effluent for month, 95,138,259 gallons.

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1894.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head.
		Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		Feet.
February 1, ...	6,300	86	56	39	51	Covered.	3.6
2, ...	7,700	59	63	26	54	"	3.6
3, ...	5,600	102	55	22	50	"	3.5
4, ...	-	-	-	-	-	"	-
5, ...	7,800	146	90	72	33	"	3.6
6, ...	10,200	159	41	62	50	"	3.8
7, ...	9,000	110	51	35	61	Drained.	3.9
8, ...	7,800	-	70	48	40	"	5.1
9, ...	7,500	101	67	58	37	"	4.6
10, ...	7,800	151	75	55	19	"	4.8
11, ...	-	-	-	-	-	"	-
12, ...	11,900	115	49	90	53	Covered.	4.8
13, ...	7,100	130	60	95	35	"	4.4
14, ...	7,100	125	67	72	43	"	4.0
15, ...	6,600	165	70	63	58	"	6.2
16, ...	8,100	163	63	56	64	"	6.0
17, ...	7,000	-	98	88	30	Drained.	7.0
18, ...	-	-	-	-	-	"	-
19, ...	10,700	140	90	66	30	"	7.6
20, ...	11,200	460	95	58	62	"	6.8
21, ...	9,300	396	157	118	68	"	7.7
22, ...	8,600	-	-	110	80	"	7.6
23, ...	7,000	387	254	122	60	Covered.	7.4
24, ...	9,400	529	281	185	90	Drained.	6.9
25, ...	-	-	-	-	-	"	7.3
26, ...	9,900	623	356	248	189	"	7.0
27, ...	7,100	682	411	152	142	"	7.2
28, ...	6,500	438	345	165	116	"	7.0

Total quantity of effluent for month, 85,279,992 gallons.

On February 19 there were about 2 feet of ice on the surface, and in places on the side opposite from the main distributing conduit it was frozen to the sand; considerable air was in the pores of the sand. During the next 10 days a strip about 6 feet in width was scraped along each lateral conduit for about two-thirds the width of the filter.

Daily Bacterial Results, Lawrence City Water — Continued.

[Bacteria per cubic centimeter.]

Date — 1894.	In River Water.	In Filtered Water from — Filter.	In Filtered Water from — Reservoir Outlet.	In Filtered Water from — Tap at City Hall.	In Filtered Water from — Tap at Experiment Station.	Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
March 1, ...	6,500	350	284	211,	180	Drained.	7.0
2, ...	9,900	410	346	157	116	"	6.4
3, ...	5,000	588	295	186	179	"	6.2
4, ...	-	-	-	-	-	"	5.5
5, ...	7,000	-	408	185	100	"	5.7
6, ...	12,200	395	306	162	104	"	5.5
7, ...	16,000	360	420	170	88	"	5.8
8, ...	18,400	-	390	182	74	"	4.3
9, ...	13,000	-	270	170	65	"	5.8
10, ...	13,000	325	310	140	280	"	5.9
11, ...	-	-	-	-	-	"	-
12, ...	9,200	711	262	110	89	"	4.3
13, ...	9,800	-	270	128	189	"	6.4
14, ...	8,600	-	240	98	112	"	6.6
15, ...	7,800	-	290	117	68	"	5.7
16, ...	7,200	198	287	191	90	"	6.0
17, ...	5,000	165	262	72	71	"	3.9
18, ...	-	-	-	-	-	"	-
19, ...	4,400	93	116	78	40	"	3.9
20, ...	7,000	99	103	50	50	"	5.3
21, ...	5,000	98	124	48	58	"	5.2
22, ...	3,000	75	195	36	53	"	5.5
23, ...	8,100	76	107	46	36	"	5.5
24, ...	5,000	65	76	42	57	"	5.3
25, ...	-	-	-	-	-	"	-
26, ...	4,500	87	94	48	80	"	5.2
27, ...	3,500	110	73	58	81	"	5.7
28, ...	3,000	83	103	57	32	"	5.6
29, ...	2,000	74	93	136	53	"	5.4
30, ...	3,700	78	110	122	96	"	5.4
31, ...	10,200	-	90	120	86	"	5.1

Total quantity of effluent for month, 88,132,282 gallons.

The ice had disappeared by March 12 and the surface was gradually scraped and graded. This took about a month, and was the third complete scraping of the surface.

Daily Bacterial Results, Lawrence City Water — Concluded.

[Bacteria per cubic centimeter.]

Date — 1894.	In River Water.	In Filtered Water from				Condition of Surface when Pumps were Stopped.	Loss of Head. — Feet.
		Filter.	Reservoir Outlet.	Tap at City Hall.	Tap at Experiment Station.		
April 1,	-	-	-	-	-	Drained.	-
2,	11,300	230	183	197	94	"	3.9
3,	7,300	101	112	70	76	"	4.7
4,	19,000	337	210	137	110	"	4.6
5,	22,500	160	70	62	136	"	4.6
6,	9,300	140	131	68	98	"	4.8
7,	19,200	350	218	75	78	"	4.3
8,	-	-	-	-	-	Covered.	-
9,	21,000	195	152	78	80	Drained.	4.0
10,	16,800	170	136	83	75	"	4.7
11,	23,000	198	134	82	76	"	4.6
12,	19,200	798	196	86	68	"	4.7
13,	22,100	720	170	88	76	"	4.8
14,	18,000	350	158	89	68	"	4.7
15,	-	-	-	-	-	"	-
16,	21,700	108	165	100	83	"	3.5
17,	8,300	85	95	125	95	"	3.9
18,	15,200	-	160	40	85	"	4.0
19,	12,000	-	-	60	55	"	4.4
20,	15,100	121	127	72	59	"	4.8
21,	25,400	180	75	47	64	"	4.7
22,	-	-	-	-	-	"	-
23,	13,000	170	96	63	60	"	2.8
24,	12,100	190	84	54	67	"	3.4
25,	6,300	226	83	73	67	"	3.7
26,	11,400	215	68	76	58	"	3.9
27,	7,800	91	76	56	70	"	3.9
28,	5,400	110	66	64	67	"	4.4
29,	-	-	-	-	-	Covered.	-
30,	5,900	98	68	50	90	"	3.1

Total quantity of effluent for month, 74,706,798 gallons.

THE FILTER

OF THE

WATER SUPPLY OF THE CITY OF LAWRENCE

AND ITS RESULTS.

By HIRAM F. MILLS, A.M., C.E.,
MEMBER OF THE STATE BOARD OF HEALTH OF MASSACHUSETTS.

THE FILTER OF THE WATER SUPPLY OF THE CITY OF LAWRENCE AND ITS RESULTS.

By HIRAM F. MILLS, A.M., C.E.,
Member of the State Board of Health of Massachusetts.

The Lawrence pumping station is by the side of the Merrimack River above the city and about a thousand feet up stream from the nearest house. The water was drawn from the river through a thirty-inch iron pipe continued to the engine house by a brick conduit four feet in diameter. At right angles with this conduit, and extending down stream from the engine house for three hundred feet along the shore, was a stone and brick filter-gallery eight feet wide and eight feet high inside, the bottom of which, as well as the bottom of the conduit from the river, was about level with the bottom of the pump well under the engine house and eleven feet below low water in the river.

The river water brought so much silt at the time of the spring and fall freshets that the shore became impermeable, and soon after the works were constructed it became evident that the filter-gallery received little or no water from the river side and the quantity received from the land side was insignificant. The works have been in use about seventeen years. For some years after they were built there was a diminution in the number of deaths by typhoid fever from the number when well water was used, and no one thought of direct poisoning by sewage of the water taken from the river nine miles below Lowell with a fall of ten feet through a rapid a mile long on the way. Many made the remark that running water purified itself in a less distance and put away any fear of contamination, while a few did not like to drink water into which the sewage of seventy thousand people was poured only eight hours before it reached the intake of the water works.

Shortly after the State Board of Health was reorganized in 1886 the Experiment Station was established at Lawrence, and it was soon found that all of the bacteria in sewage, amounting generally to

several hundred thousand in every thimbleful, could be removed by slow intermittent filtration; also, that the same result could be attained by filtering water at a more rapid rate, but not at a rate that rendered it practicable to apply to a city's water supply. Experiments of the Board with rapid mechanical filters showed a large percentage of the bacteria remaining in the filtered water, and experiments at Berlin indicated that the continuous filters of that city allowed some of the germs of typhoid fever to pass through; enough to cause sickness in the city.

In 1890 a careful study of the deaths from typhoid fever in the cities of the State showed that the cities of Lowell and Lawrence had nearly three times the average number, from the same population, in other cities; and that during the season — August, September and October — when other cities had the most typhoid fever, Lowell and Lawrence had about the same number as other cities, but a month or more later the deaths in Lowell reached three and four and eight times the deaths in other cities, and after another month those of Lawrence increased by a still greater ratio, so that in some years the deaths in January and February from this disease were more than the actual number in Boston, with ten times the population. This condition, following year after year, made it so evident that the disease came down the river to Lowell from the cities and towns above, and then came with greater intensity from Lowell to Lawrence, that the State Board of Health made strenuous efforts to produce a filter that would remove all disease-producing germs that could be applied to it, and at the same time filter rapidly enough to serve for a city's water supply. Billions of typhoid-fever germs were cultivated and applied to filters of different construction, and in 1891 we succeeded in removing all that were applied when filtering two million gallons per acre daily. Then the Board advised the city of Lawrence to filter its water, and offered to show how to do it.

Such a filter would require some layers of quite fine sand, and it was thought necessary to first take out the very fine river silt from the water by means of a coarser sand filter at the river bank. Further experiments showed that the construction of a filter at the river bank with a sand coarse enough to allow the river silt to be deposited upon it, if removed promptly, would serve to remove ninety-eight per cent. of all of the bacteria of the river water and a still larger per cent. of the disease producing germs; and considera-

tions of economy and the immense advantage of such a filter with the probability of this or none, with an unbelieving public, induced the State Board of Health to advise the city to immediately construct such a filter and save the fifty-seven lives, which was the annual excess of deaths by this disease over that of the same number of inhabitants in cities of the State having a good water supply.

In 1892, in view of the possibility of cholera getting into Lowell and making it necessary to cut off the Lawrence water supply, the city government made an appropriation for beginning the work of constructing the filter in accordance with the advice of the State Board of Health and under its direction.

The general design was to excavate the bed and bank of the river to seven feet below low water for a width of about one hundred and fifty feet out from the old filter-gallery and from the high water shore down stream from this, making a length of about seven hundred and fifty feet and an area of excavation of two and one-half acres (see Plate I., Fig. 7). The suitable material from the excavation was to be put into a tight embankment, on the ends and river side, carried to nine feet above low water in the river or high enough to exclude the highest freshets. The excavation was to be then filled for a depth of about five feet with suitable filtering sand properly underdrained into the old filter-gallery and into a small perforated conduit in extension of the gallery.

The top of the sand, being two feet below low water in the river, could by a proper inlet be flooded by gravity to a depth of about two feet, thus forming a shallow pond of two and a half acres area, which would gradually filter downward through the sand to the underdrains and be conveyed to the old gallery, and through this to the pump-well.

One of the essential qualities of the design required that the inlet water should be shut off once a day and the pumps kept running until the sand was uncovered and the water within the sand drawn out, so that the sand could fill with air from top to bottom.

This condition of filling the sand with air daily was regarded necessary to insure the burning up of the organic matter which penetrated the sand below the surface and forming nitrates in the water, thus producing conditions the most unfavorable for the continuation of the life of bacteria within the water in their passage through the sand and in the water after leaving the filter.

There is nearly air enough in our drinking waters to supply the

oxygen which is necessary to carry on the process of nitrification when the water comes in contact with the grains of sand which have nitrifying bacteria adherent, but the addition of the air which enters the sand by drawing the water out of it once a day causes a more complete burning up of the organic matter in the water, which is the nitrifying process spoken of.

The question may arise, if water contains so much air why does not nitrification take place in the reservoir? The reason is that nitrification will not take place unless the water with the air comes in contact with certain bacteria which in some unknown way cause the process to be carried on. These bacteria attach themselves to the grains of sand of the filter and remain there, and when air is present they can in a short time cause the nitrifying process to be carried on so completely that nearly all of the organic matter in the water is burnt up, and with this burning the disease germs in the water are killed.

The carrying out of this design required some original investigations upon the head required to convey a definite quantity of water through sands of different size of grain and through gravel stones of different sizes. The circumstances of the location would allow an expenditure of head of one and a half feet when the surface of the sand was clean, through the sand and through the underdrains and conduit to the pump-well, when drawing the full quantity of 2,000,000 gallons per acre per day, or 5,000,000 gallons for the field.

The sand selected to meet these conditions was of two sizes, the finer of the two being placed directly over the underdrains and for five feet each side of them; and the coarser occupying the remaining twenty feet between the drains, and through which the water would move laterally and use up about the same amount of head as when flowing directly downward through the finer sand.

The coarser sand was such that 70,000,000 gallons would flow in twenty-four hours through a foot in depth, covering an acre, with the expenditure of one foot head; and the finer sand would convey 50,000,000 gallons under the same conditions. In moving vertically downward five feet through the finer sand, 10,000,000 gallons would flow through with the expenditure of one foot of head, but the water moving laterally through the coarser sand toward the underdrain would crowd the stream in the finer sand below the surface so that the water going through the surface in a width of ten feet would

be, near the bottom, pressed into a channel of perhaps not more than five feet in width and thus decreasing the quantity that could pass with one foot head to perhaps 7,000,000 gallons per acre per day.

As the water was to flow through the sand with a daily intermission of several hours, the actual time of flowing would be, say two-thirds of the day, and would allow between four and five millions to pass. This is the quantity that could pass with one foot loss of head through the sand when the surface of the sand is clean, but the fine mineral sediment and the organic matter brought by the river water choke the surface and reduce the quantity of water that can pass through, and in order not to have to clean the surface too frequently, the sand when clean should be able to convey two or three times the quantity required.

It was expected, from experiments that had been made with this water, that ordinarily with sand grains of the sizes here used, the surface would have to be cleaned by removing from an eighth to a quarter of an inch and replacing with clean sand once a month, and that during freshets, when more sediment comes in the river water, the surface would have to be cleaned oftener.

If the surface should not be cleaned as often as necessary, the result would be a lowering of water in the pump-well and if neglected until the surface became so impervious that the one or two feet in depth of water over the surface were not sufficient to force the required quantity through the upper layer, the drawing down of the pump well to the bottom of the sand would give no relief, the surface would have to be cleaned.

Economy of construction, the providing for a nearly uniform rate of filtration through every square foot of the area of the filter, and applying the water to the surface of the sand in a valley so that as it is filled daily there will not be a current over the surface of the sand sufficiently rapid to move the sand grains, caused the following section to be adopted.

The underdrains were arranged to be thirty feet apart. The excavation was not made to a uniform depth of seven feet below low water in the river, but was made to the depth of eight feet for a width of five feet where the underdrains were to be, and to the depth of six feet for a width of five feet at ridges between the underdrains, with slopes of one foot in ten feet between (see Plate I., Figs. 3, 4, 5 and 6). Over these ridges the sand was filled only to the depth of three feet for a width of five feet and beyond this the surface of the

sand rose one foot in twenty feet and then ran level for five feet at a height of six feet above the bottom. Such ridges and hollows formed the general longitudinal section of the bed.

The direct conduit through which water was formerly supplied to the pump-well from the river is at the up-river end of the filter-bed (Plate I., Fig. 1). It is furnished with a gate at the inner end, and the top was pierced and a chimney built about forty feet outside of the engine house, and projecting through the side of this chimney were set two iron pipes two feet in diameter with a gate in each, having its centre two feet below low water in the river. One of these is intended to supply an extension of the works up the river; the other discharges into an open conduit which extends along the inside of the embankment nearly the whole length of the bed. At the upper end the section is a semi-circle six feet in diameter. The edge toward the bed remains level throughout its length at three feet below low water of the river, but the bottom rises gradually from three feet below the edge to six inches below at the lower end, and this continues by a curve and crosses the bed in the down-river valley with the edges level, but the bottom rises so that the depth at the end is only one inch. In each of the valleys, thirty feet apart, extends from this main conduit a shallow carrier of concrete lined with cement mortar, having its edges level with the edge of the conduit, and extending from the conduit to thirty-two feet from the opposite side of the bed. These are two feet wide and three inches deep at the conduit, and one foot wide and one inch deep at the end. In this way there are formed edges of water carriers at the same level and about one and one-third miles in length, over which the water reaches the sand, and as within two feet from these edges the surface of the sand rises with a slope one foot in ten there is very little perceptible current over the sand as the water leaves the carriers.

The conduit is made of cobble paving stones four to six inches through, laid in Portland cement mortar on a layer of gravel eight inches thick and made smooth within by a coat of mortar. The carriers are made of cobble stones about four inches in diameter, laid in Portland cement mortar on the sand, and made smooth within. At the junction with the conduit the carriers are widened by curves to prevent washing of sand at the turn.

The underdrains enter the old filter-gallery through holes cut in the wall. (See Plate I., Fig. 2.) Glazed sewer pipe surrounded by stones are used for about four-tenths of the distance from the

gallery across the bed, beyond which are layers of stones of different sizes without pipes. Beginning at the gallery is one length of ten-inch pipe, then two lengths of eight-inch pipe, then from thirty-five to sixty-five feet of six-inch pipe, ending with three lengths of four-inch pipe. These pipes are laid apart so that the spigot approaches but does not enter the bell, and they are surrounded by a layer of about four inches of stones about two inches in diameter. (See Plate I., Figs. 3, 4, 5 and 6.) Other layers, decreasing in size through one and one-half inches, three-quarters of an inch, three-eighths of an inch and three-sixteenths of an inch, are applied in the form shown by the sections and plans, and the latter being spread out to a width of seventeen feet is covered by one inch of coarse mortar sand which spreads to a width of twenty feet. Upon this rests the filtering sand from four to five feet deep.

The valley in the excavation is deepened in the part occupied by the pipe so that the pipe has a slope of one foot in one hundred feet. The pipe was applied as far from the filter-gallery, or conduit in extension of the gallery, as it and the stones surrounding it cost less than the much larger area of stones required to give the desired freedom of flow. Beyond this the large stones were spread out to the widths and with the depths required to give the desired flow.

To determine how much head would be used in flowing through layers of sand and layers of stones of different sizes experiments were made under my direction by Mr. Allen Hazen, the chemist in charge of the Experiment Station of the State Board of Health. As is well known, the head required to convey water through ordinary pipes varies with the square of the velocity, but with extremely small pipes and through the interstices of fine sand the head required to convey water varies with the velocity and with the temperature, more head being required with colder water. Through coarse sand and through gravel stones the head varies with powers of the velocity between the first and second powers, increasing with the size of the grains or of the stones. For sands, ten per cent. of whose grains are as small as two millimeters or eight-hundredths of an inch in diameter, the quantities of water that would pass through an acre in area with different depths and sizes of grains were determined by the following formula deduced from experiments which had been made up to the time of constructing this filter: $Q = \frac{800\, h\, d^2}{l}$ in which Q expresses the quantity of water in million gallons per acre per day, h the acting head in feet, l the distance flowing through the sand in

feet, and d the maximum diameter in millimeters of the finer ten per cent. of the sand grains.

This formula expresses quite satisfactorily the quantity of water that will pass through clean sand from which air has been pushed out when the temperature is about 50° Fah., and is convenient to use in comparing sands of different sizes; but Mr. Hazen found that the resistance was nearly twice as great when the temperature was near the freezing point as when at summer heat, and he afterward determined an expression from the experiments, giving the velocity of flow through sands at any temperature, which may be found on page 553 of the Report of the State Board of Health for 1892.

The sand used in the Lawrence filter which was placed directly over the underdrains and five feet on either side had the coarser grains of the finer ten per cent. twenty-five hundredths of a millimeter in diameter, and by the above formula when the head used is equal to the distance which the water passes through the sand the quantity of water that could pass through an acre in twenty-four hours would be fifty million gallons. If two million gallons were applied to an acre in sixteen hours, or the equivalent of three million gallons in twenty-four hours, and this were crowded into one-half its area near the bottom of the sand, by the lateral pressure of the water coming towards the underdrains through the ten feet of coarser sand on each side, the resistance would be like that of four and a half million gallons traversing six feet in depth of sand, for which the head required would be fifty-four hundredths of a foot.

As the circumstances here allowed of a loss of head through the sand of one foot, the remaining head, from fifty-four hundredths to one foot, was the amount allowed for increased obstruction through the sand due to air and to lower temperature.

By a similar process of computation the coarser sand occupying the remaining twenty feet of the thirty feet between underdrains was found to be able to convey its proportion of the water to the underdrains with a like loss of head; hence the arrangement presented by these sections enabled all parts of the area of the filter to transmit nearly their proper quantity of water.

With this loss of head through the sand when clean, there would be a noticeable increase in loss by a slight deposit of sediment upon the surface, and depending upon this narrow margin it was deemed practicable to construct and use for a term of years a single bed which was to be cleaned regularly each month, a portion being

cleaned every day during the interval when the bed is resting; and this portion when cleaned is not capable of conveying so large a quantity of water that it cannot be properly purified in its passage, unless there be an extreme drawing down of the head which would require very close watching at the pumps.

When it becomes impracticable to properly purify the full amount of the city's supply by the present bed it is designed to construct another bed extending up the river from the intake, to be supplied by the second two-foot valve mentioned as built into the side of the chimney rising from the old intake.

We have followed the water through the sand and considered the head lost in its passage. There is still some head to be used in passing through the layers of stone and the underdraining pipes.

In considering the loss of head through fine sand and through coarser material to very large gravel stones, we find the loss increasing with the first power of the velocity, and with powers increasing with the coarseness from the first to the second power of the velocity; hence the most convenient method of presenting what our experiments have shown is in the form of a table which was used in distributing the remaining allowable loss of head of about half a foot in addition to the one foot through the sand, so that it should still serve to make the passage of water nearly uniform from all portions of the surface of the bed.

This table, though capable of improvement by additional data, led to conclusions which proved satisfactory in this case.

Quantity of Water Flowing through Gravel Stones at Different Heads.

[Quantity flowing in 1,000,000 gallons per acre daily.]

Loss of Head in Terms of Distance through Gravel.	Size of Gravel Stones in Millimeters and Inches, the Finest 10 Per Cent. Finer than —							
	3 Mm. 0.12 In.	5 Mm. 0.20 In.	8 Mm. 0.32 In.	10 Mm. 0.39 In.	20 Mm. 0.79 In.	30 Mm. 1.2 In.	40 Mm. 1.6 In.	50 Mm. 2.0 In.
0.0006 . . .	4	12	22	35	90	170	280	410
0.001 . . .	7	23	43	65	160	300	480	690
0.002 . . .	15	43	84	120	300	490	720	1,040
0.004 . . .	29	83	160	230	520	790	1,070	1,360
0.01 . . .	72	185	320	420	890	1,280	1,670	2,150
0.02 . . .	136	320	500	630	1,280	1,800	2,340	3,030
0.05 . . .	300	600	950	1,140	2,030	2,862	3,734	4,800
0.10 . . .	530	1,000	1,400	1,650	2,850	4,044	5,280	6,800

By the aid of this table the underdrains, formed of layers of stones of different sizes, were proportioned as shown in the accompanying plan and sections. The larger stones were selected by hand, and if soiled were washed. The smaller sizes were selected by screening, and in this way all sand was removed. The stones of the two larger sizes were carefully placed at the open joints of the pipes to allow water to enter as freely as possible; the other layers were shovelled to place.

In extension of the old filter-gallery, to serve to conduct the water from the down-river underdrains to the gallery, a conduit was built with walls four inches thick of brick laid in Portland cement mortar, with the mortar left out of the end joints, which were a little more than an eighth of an inch wide. This conduit was two feet in diameter for a length of 105 feet, then 20 inches in diameter for a length of 120 feet, then 16 inches in diameter for a length of 65 feet, then 12 inches in diameter for a length of 30 feet, beyond which were ten-inch, eight-inch and six-inch glazed pipes, in lengths of 30 feet, laid as in the underdrains. This conduit was surrounded by the large stones 2 inches in diameter for a thickness of 4 inches, with layers of decreasing sizes around this, making a total thickness of about 8 inches.

Great care was taken to deposit the filtering sand so that the mass should be as homogeneous as possible. It was deposited in two layers. The first layer was covered with planks as fast as laid, upon which the loads were hauled, and these were dumped upon the planks near the edge, so that a part of the load ran over the bank and the other part was shovelled over. If the edge of the bank remained exposed to the wind and sun the coarser material would appear on the surface and run down. Such an edge was shovelled over before an addition was made.

The second layer was dumped upon the planks resting upon the lower layer and shovelled up to grade, and upon taking up the planks the lower layer was shovelled over to the depth of one foot and a half to remove the packing of the sand which was evident under the planks, sometimes to a depth of one foot.

It will be evident that watchful care was necessary in laying the underdraining stones to see that no bar of finer material crossed it in any direction. In fact, the success of the filter depended largely upon careful and conscientious superintendence of the construction of the underdrains and the bed. This was accomplished by Mr.

Charles C. Campbell, who had an intelligent appreciation of the essentials to success and most scrupulous care that the work should be done as directed.

Sand for the filter was obtained from a bank about seven-eighths of a mile away, where layers and pockets were found containing all kinds, from the very fine, almost impervious, sands to large gravel stones, and much unsuitable material had to be removed in selecting layers from which suitable sand could be obtained. By judicious selection, screening and mixing the two kinds of sand were obtained and wheeled to piles for loading. These piles were frequently tested by half filling with sand a cylinder six inches high and three inches in diameter, having a wire bottom. The sand was packed slightly and covered with a wire screen and the cylinder filled with water, and the time observed that it took the water to pass below the surface of the sand. Time limits for the two grades were determined at the laboratory, making correction for the temperature of the water, and the accuracy of these tests at the bank was determined by occasionally taking duplicate samples to the laboratory and making regular mechanical analyses by means of sieves.

The filter was completed, at a cost of about $65,000, in the forenoon of Sept. 20, 1893, just about one year from the time of commencing, although there were four or five months when work was suspended; and in the afternoon of September 20 the inlet gate was opened and the water filled the open conduit along the base of the embankment, ran into the carriers, and gradually flowed over the one and one-third miles of level edge and entered the sand, disappearing in a short distance at first, but gradually as the sand was filled extending further from the carriers and filling the bottom of the twenty-six valleys, and then rising slowly up their sides and covering the ridges, forming a shallow pond of two and a half acres. Then the pumps were started, and when running at the rate of five million gallons in twenty-four hours we found that the difference in level between the water over the filter and in the pump-well was seventeen inches.

The water first coming through the filter contained an extremely fine dust in suspension, probably washed from the surfaces of the stones and underdrains. In the first ten days the chemical changes in the water were as follows: the albuminoid ammonia was reduced from 0.0168 to 0.0108 in parts per 100,000. The free ammonia was reduced from 0.0113 to 0.0072, and the nitrates were increased from 0.0120 to 0.0200 part. The color was reduced from 0.36 to 0.28 on

the scale for color. Since that time the average change has been in albuminoid ammonia from 0.0187 to 0.0104; free ammonia from 0.0067 to 0.0087, and the nitrates from 0.0140 to 0.0390 part, and the color reduced from 0.42 to 0.35. The hardness of the water has increased from 1.3 to 2.9.* This change is probably partly temporary, due to absorption of lime from the conduit and carriers, but it is partly due to ground water, as it was the greatest when, in the latter part of February and early part of March, there was the greatest loss of head through the filter and consequently the greatest draft from the ground. At the same time there was an increase in the free ammonia of the filtered water, evidently due to the same cause; but this cause was an exceptional condition due to the surface of the bed not having been cleaned for three months, which will probably not occur again.

While the improvement of the water by the removal of the suspended matter and the burning up of the organic matter that was readily oxidizable was very satisfactory, the most important change and the real object of the construction of the filter was the removal of bacteria, and especially of those kinds of bacteria that are dangerous to health, known as disease germs.

The removal of bacteria is not merely a straining process; it is accomplished by making conditions unfavorable to the life of bacteria in the passage through the filter, which conditions grow with the proper use of the filter. In the first three days 75 per cent. of the number of bacteria applied came through the filter. In the next three days 30 per cent. came through, but in the first week in October only 4 per cent. came through, and in the next week 2 per cent.; that is, during the first three weeks' use the number of bacteria in the effluent rapidly decreased to 2 per cent. of the number applied, and from that time to the present,† excepting on two occasions when work on the filter or in the pump-well interfered with the results, the effluent from the filter has contained 1.7 per cent. of the number of bacteria contained in the river water, the filter having removed 98.3 per cent. of all of the bacteria in the water applied to it.*

But the result given to the people is better than this. It appears that with the removal of those parts of the organic matter that are

* For results in detail of examinations of water from the Lawrence water works before and after filtration see pages 530-541, also 181-186.

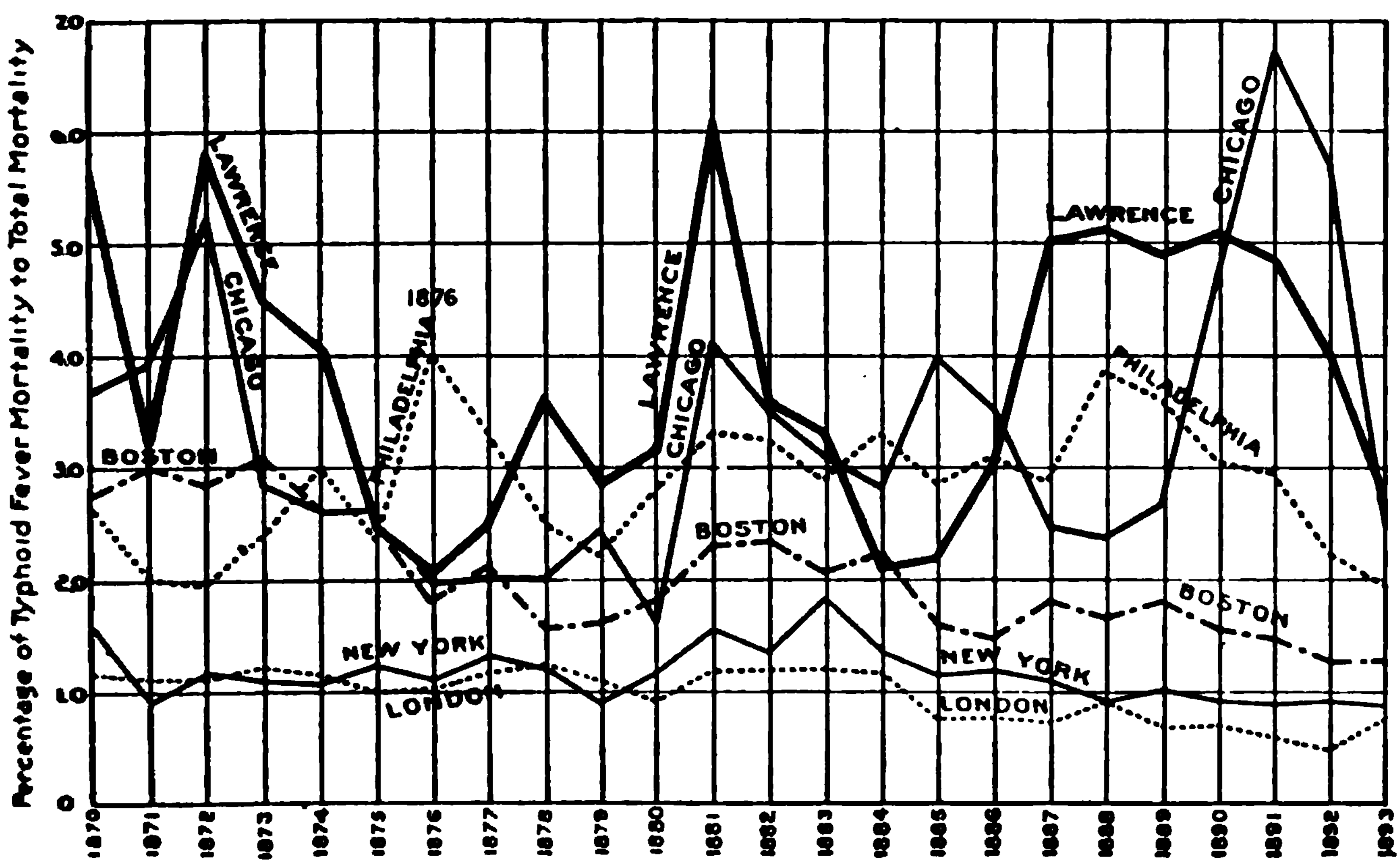
† June 1, 1894.

easily oxidized the food material of the bacteria has been removed, and as the water flows on through the reservoir and through the pipes the conditions of life are still unfavorable for the bacteria, and they go on decreasing, so that the numbers found at the outlet of the reservoir are but one and two-tenths per cent. of the numbers in the river water; and at the tap in the city hall the numbers of bacteria found are but nine-tenths of one per cent. of the numbers in the river water. More than ninety-nine per cent. of all of the bacteria of the river water have been removed.

The experiments of the State Board of Health go to show that with this result we can rely upon the complete extinction of all of the disease producing germs that may have been in the water.

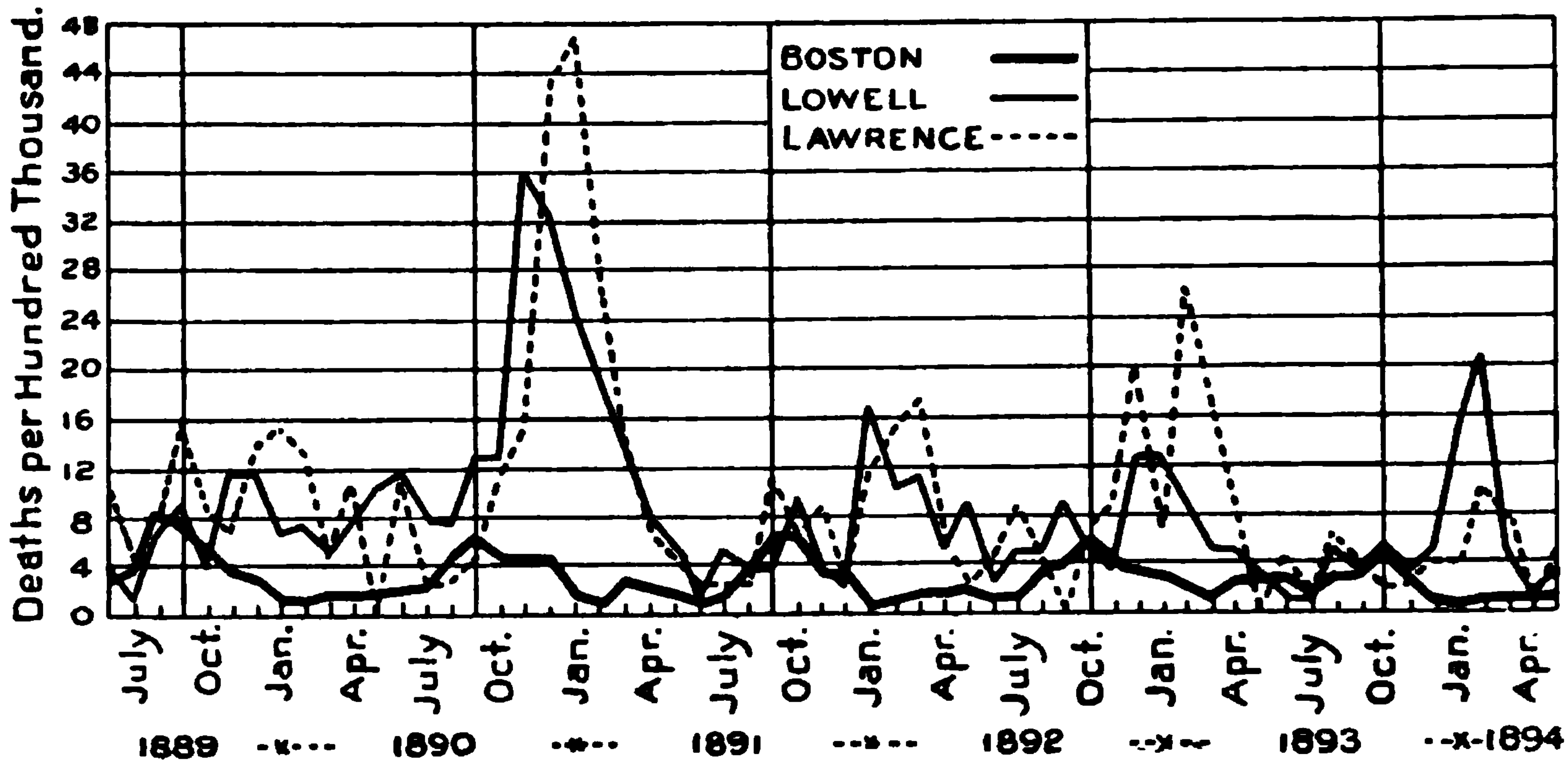
We have seen the effect of the filter upon the bacteria of the water applied to it; we will now seek the effect of the filter upon the inhabitants of Lawrence. It has been stated that the deaths from typhoid fever in Lawrence were about three times those of other cities in the State. Its relation to other cities from a broader field is shown by the following diagram, in which are given the percentage of mortality from typhoid fever to the total mortality in London, New York, Boston, Philadelphia, Chicago and Lawrence.

Diagram showing Percentage of Typhoid Fever Mortality to Total Mortality in London, New York, Boston, Philadelphia, Chicago and Lawrence from 1870 to 1893.



That the typhoid fever that has in the past affected Lawrence so seriously has come down the river year after year may be confirmed by the following diagram containing three broken lines. The heaviest

Diagram showing Deaths per 100,000 Inhabitants in Boston, Lowell and Lawrence from June, 1889, to May, 1894.



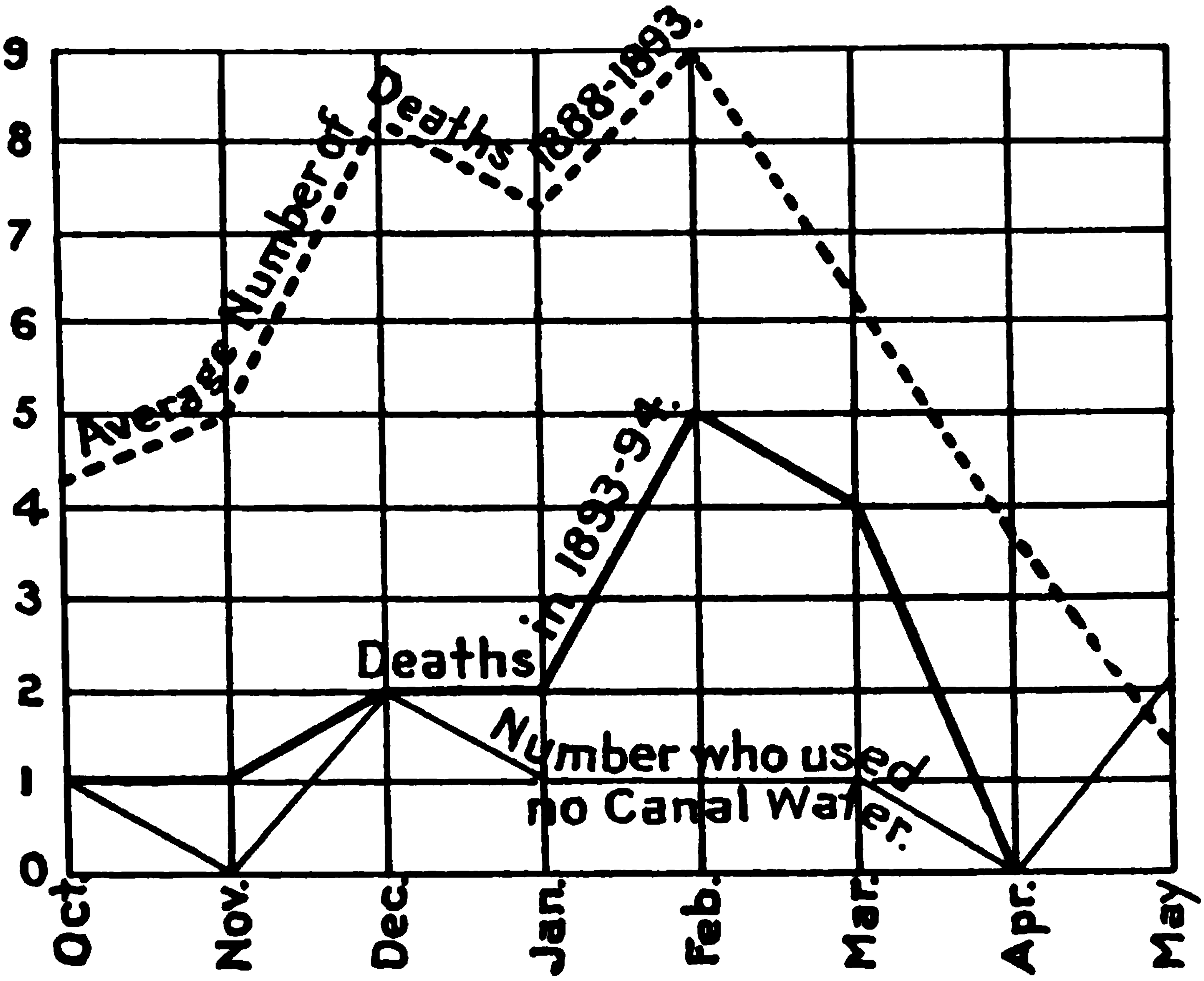
line indicates the number of deaths from typhoid fever in 100,000 inhabitants in the city of Boston in each month in the past five years. This line represents approximately the number of deaths from this disease in 100,000 inhabitants in the cities of the State and the months in which they occur. It will be seen that the months of greatest prevalence are September and October of each year. A vertical line has been drawn at such time of prevalence in each year at Boston, and this is nearly the time of its prevalence in our cities generally.

We see that in these months the disease prevailed to as great an extent in Lowell and Lawrence, but that following this period in about two months it prevails at Lowell to a much greater extent, and one or two months later it prevails to a still greater extent in Lawrence. This is the case year after year until during the past winter, when in February and March there was an increase in Lawrence following that at Lowell, but instead of being in greater numbers, as in former years, it was to only about half as many per 100,000, and the cause of this increase will now be considered.

In the following diagram the average number of deaths from typhoid fever at Lawrence for each month from October to May, in the preceding five years, are given by the heavy dotted line; and

the number during the past eight months are given by the heavy full line.

Typhoid Fever in Lawrence.



The total number for the eight months in past years has been forty-three, and in the present year seventeen, making a saving of twenty-six. Of the seventeen who died nine were operatives in the mills, each of whom was known to have drunk unfiltered canal water, which is used in the factories at the sinks for washing.

The finer full line shows the number of those who died month after month who are not known to have used the poisoned canal water. The whole number in the eight months is eight.

It is evident from the previous diagram that the numbers above the fine full line, here, follow after those at Lowell in the usual time, and were undoubtedly caused by the sickness at Lowell; but we have satisfactory reason to conclude that the disease was not propagated through the filter but that the germs were conveyed directly into the canals and to those who drank of the unfiltered canal water. Among the operatives of one of the large corporations not using the

canal water there was not a case of typhoid fever during this period. Warnings have been placed in the mills where canal water is used to prevent the operatives from drinking it.

We find, then, that the mortality from typhoid fever has, during the use of the filter, been reduced to 40 per cent. of the former mortality, and that the cases forming nearly one-half of this 40 per cent. were undoubtedly due to the continued use of unfiltered river water drawn from the canals.

The effect of the filter in preventing the communication of diarrhœal and other diseases carried by water can be given after the season of the year when these diseases prevail. We can say further at present that the physicians have very generally reported a marked improvement in the health of the people since the filter came into use.

The study of this problem and its solution have established with more of certainty than ever before three important points in sanitary science : —

1. The insufficiency of the self-purification of streams.

2. The ready conveyance of typhoid fever down a stream by sewage-polluted drinking water.

3. The practicability of protecting a community against an infected drinking water supply by natural sand filtration.

SEWAGE PURIFICATION

OF

CITIES AND TOWNS IN MASSACHUSETTS.

SEWAGE PURIFICATION OF CITIES AND TOWNS IN MASSACHUSETTS.

The last annual report (1892) contained a paper upon the "Sewage Disposal of Cities and Towns in Massachusetts by Intermittent Filtration," which was accompanied by chemical analyses of the sewage and effluent from the works of the three places described, viz.: Framingham, Marlborough and Gardner. Owing to the time required for the publication of that report it was feasible to include in it analyses made up to the end of July, 1893. In the present paper results from sewage disposal works at several additional places are given, and analyses of sewage and effluent from the three places mentioned above are included only from the first of August to the end of the year. A short description of each of the systems examined is given in the following pages, and to assist the reader in understanding the conditions at the various places some of the statements made last year are repeated.

The first plant for the disposal of town sewage by intermittent filtration in Massachusetts was constructed at Lenox in 1876. A system for the disposal of the sewage of a portion of the town of Amherst, partly by filtration but chiefly by irrigation, was constructed about 1881, and a small system for the disposal of sewage by intermittent filtration was introduced at Medfield in 1886. Since the last date the towns of Framingham and Gardner and the city of Marlborough have constructed and are now operating works for the disposal of sewage by intermittent filtration, and a new disposal field has been constructed and is in use at Lenox. The city of Brockton (population in 1890, 27,294,) is at present constructing works of this kind, which will be operated in 1894. There are, also, several large institutions which dispose of their sewage by intermittent filtration. The sewage of the city of Worcester is treated by chemical precipitation, as described on page 341 of this report.

In order to learn the results obtained by the systems of sewage disposal in the various places, the State Board of Health has caused many analyses of the sewage and effluent from the filter-beds at Framingham, Gardner and Marlborough to be made, and has also made one or more chemical examinations of the sewage and effluent from the sewage disposal works at Amherst, Lenox, Medfield, Westborough and Wellesley College. The results of these analyses are given in connection with a description of the works in the pages which follow. Analyses made by the chemists at Worcester, showing the results obtained at the chemical precipitation works there, have already been given on page 345.

Sewage Disposal at Amherst.

The population of the town in 1890 was 4,512. Sewerage facilities have been provided only for portions of the main village, and the sewage is disposed of by two systems.

The first system, begun in 1881 and subsequently extended, collects the sewage from about 1,000 inhabitants. The sewage flows to a settling tank about a mile south-east of the village and thence through a pipe 520 feet long into Fort River.

By the second system, since 1886, the sewage of a portion of the thickly populated part of the town north of the town hall has been applied, after settling in a tank, to a field having an area of about three acres and a slight slope, located about half a mile north of the village. It is said that there are about 300 people connected with this system, and storm-water is excluded from the sewers. The sewage is conducted by a ten-inch pipe to a settling tank located on the upper side of the disposal field. The tank is about 4 feet deep and holds about 500 gallons. The outlet pipe is arranged to avoid drawing the scum from the surface of the tank, and discharges into a long ditch running along the upper side of the field, from which the sewage is discharged through openings in its sides. The place of discharge is changed from time to time by blocking up the existing opening and making a new one. The sludge from the settling tank is removed at intervals and composted. Analyses of the sewage before and after settling in the tank are given below. There is no opportunity to obtain a sample of the effluent from this field, as the sewage sinks into the ground and does not reappear in such a way that a sample can be collected.

Chemical Examination of Sewage from Amherst.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Residue on Evaporation. Total Residue. Dissolved.	Residue on Evaporation. Total Residue. Suspended.	Residue on Evaporation. Loss on Ignition. Total.	Residue on Evaporation. Loss on Ignition. Dissolved.	Residue on Evaporation. Loss on Ignition. Suspended.
	1892.									
11,385	Nov. 25,	Decided.	Heavy, gray.	1.20	104.50	27.50	77.00	84.50	11.80	72.70
11,386	Nov. 25,	Decided.	Heavy, gray.	1.50	39.90	27.40	12.50	21.50	11.30	10.20

Chemical Examination of Sewage from Amherst — Concluded.

[Parts per 100,000.]

Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.* Unfiltered.	Oxygen Consumed.* Filtered.	Iron. Unfiltered.	Iron. Filtered.	Hardness.
1.9200	.6300	.4060	.2240	3.44	.0000	.0000	6.8800	0.7740	.0750	.0500	6.7
1.2000	.3420	.2480	.0940	3.43	.0000	.0000	6.1490	3.9130	.0800	.0600	4.9

Odor, offensive. — The first sample was collected from the main sewer of the northerly system as it discharges into the settling tank. The last sample, from the pipe which conveys sewage from the settling tank to a ditch on the sewage disposal area.

* The determinations of Oxygen Consumed, given in this paper, were made after boiling five minutes.

Sewage Disposal at the Norfolk County Jail, Dedham.

Chemical Examination of Water from the Brook which flows from Fisher's Ice Pond above and below the Sewage Disposal Area of the Norfolk County Jail.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		[illegible]	[illegible]	[illegible]	Total.	Loss on Ignition.	Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.		
	1893.														
9635	Jan. 1	Slight.	Slight, dark.	0.30	4.60	1.70	.0018	.0188	.0130	.0058	.56	.0080	.0001	.3725	1.6
9636	Jan. 1	Slight.	Slight, dark.	0.30	4.70	1.30	.0022	.0116	.0082	.0034	.56	.0100	.0001	.3650	2.1

Iron, in each sample, .0050. Odor, distinctly vegetable, disappearing on heating. —— The first sample was collected about 500 feet above the sewage disposal area and the last a very short distance below it. Sewage had been discharged upon the area about 6 hours before the samples were collected.

It is evident from the analyses that no sewage effluent was present in the sample collected below the disposal area.

Microscopical Examination.

No. 9635. Diatomaceæ, *Asterionella*, 2; *Meridion*, 6; *Synedra*, 2; *Tabellaria*, 1. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 48. Total, 64.

No. 9636. Diatomaceæ, *Meridion*, 2; *Synedra*, 1. Fungi, *Crenothrix*, 3. Miscellaneous, *Zoöglœa*, 28. Total, 34.

Sewage Disposal at Framingham.

The town of Framingham (population in 1890, 9,239,) contains three villages, of which South Framingham is by far the most populous, and up to the present time is the only village sewered.

The sewerage system was put in operation near the end of the year 1889, and at the end of the year 1893, 610 dwelling-houses and 41 business blocks, stores, factories, etc., were connected with the sewers. In addition to this the sewage of the women's prison (population about 350), located in the town of Sherborn, just beyond the Framingham line, is taken care of by this system.

Storm-water is excluded from the sewers, and a continuous system of underdrains was laid beneath the principal sewers to collect and carry off the ground water. The amount of sewage flowing during a season of high rainfall, however, is fully three times the ordinary flow. The main underdrain discharges by gravity into a brook, and the character of the water discharged by it can be seen by reference

to a table of analyses on page 153 of this volume.* The average amount of sewage pumped and purified in 1893 was 218,000 gallons per day.

The sewage, after collection in a pair of receiving reservoirs having a total capacity of 431,000 gallons, is pumped during the day-time to the filtration area, which is located about two and one-half miles north-east of the village of South Framingham. This area, a more detailed description of which, accompanied by a plan, may be found in the annual report of the Board for 1892, page 560, covers about seventy acres, much of which is quite level and at an elevation of about 20 feet above Bannister Brook. An area of about twelve acres has been specially prepared for filtration by dividing it into ten beds of convenient size, removing most of the loam, which was used in the construction of embankments between the beds, and by levelling the surface. Six of the beds are underdrained to a limited extent.

In 1893 about nine acres of the prepared beds were planted with field corn (maize), and the remainder with squashes, beans, potatoes and cabbages. The crops were very satisfactory, especially the field corn, and received only ordinary attention. The preparation of additional filter-beds is under way in order to increase the area to be devoted to farming purposes. The present area, however, is amply sufficient for the disposal of the sewage.

A reasonable objection has often been made to the cultivation of crops in connection with intermittent filtration, where the area is small, owing to the danger that, in order to avoid injuring the crops, the flow of sewage at certain seasons of the year will either be concentrated on a small portion of the area or allowed to escape unpurified. In the case of Framingham, however, the cultivation of crops has had a favorable effect upon the purification of the sewage by inducing the preparation of additional filter-beds, by loosening the soil by ploughing and other disturbances of the surface incident to cultivation, and by the removal by the crops of matters brought to the beds in the sewage.

The surfaces of nine of the filter-beds were left during the winter of 1893–94 in hills and furrows, and without disturbance, after the crops

* Analyses of water from this underdrain are also given in the annual reports of the Board for 1890, 1891 and 1892, pages 149, 131 and 126, respectively. The first sample analyzed was collected before any sewage had been admitted to the sewers, and the character of the water has not changed materially since sewage was admitted.

had been removed from them. The remaining bed was ploughed and wide furrows made, about 6 feet apart, at right angles to the carriers along the side of the bed from which the sewage is applied. It was found that this bed gave the most satisfactory results, particularly when there was much snow on the ground. It is also to be noted that the beds where the surface is left in hills and furrows are much more efficient in winter than beds with level surfaces.

The quality of the sewage and of the effluent from several different places may be seen by the tables of analyses on the following pages. The sewage is ordinary town sewage, discolored and somewhat modified in character at times by a considerable amount of spent dyes discharged into the sewers from the straw goods factories in the town.

With regard to the purification effected at Framingham it may be said that the conditions for filtration are very favorable, owing to the large area of land in use in proportion to the amount of sewage treated, the porosity of the material, which has an effective size of 0.32 to 0.42 millimeter, and the depth to ground water. Another favorable condition is the high temperature of the sewage in winter (48° to 50° F.) due chiefly to the fact that the water supply of the

Chemical Examination of

[Parts per 100,000.]

			Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
	Number.	Date of Collection.	Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1893.									
1	10807	Aug. 15	Thick, opaque.	Cons., dark.	0.40	42.50	33.20	9.30	20.40	13.10	7.30
2	10924	Aug. 30	Decided, milky.	Heavy, dark.	0.60	49.60	29.30	20.30	25.00	9.30	15.70
3	11006	Sept. 11	Decided, thick.	Cons., dark.	-	31.60	28.20	3.40	12.00	10.00	2.00
4	11081	Sept. 25	Decided.	Heavy, dark.	-	36.80	31.20	5.60	12.80	12.00	0.80
5	11184	Oct. 12	Thick.	Cons., gray.	0.70	46.80	40.60	6.20	21.20	15.60	5.60
6	11283	Nov. 1	Decided.	Cons., black.	-	108.00	46.00	62.00	68.20	14.00	54.20
7	11322	Nov. 10	Decided.	Cons., gray.	0.70	33.40	29.40	4.00	12.80	10.40	2.40
8	11414	Nov. 29	Thick, black.	Heavy, black.	1.00	65.00	46.20	18.80	27.40	12.80	14.60
9	11491	Dec. 18	Thick, dark.	Heavy, dark.	0.60	40.60	33.20	7.40	15.20	8.20	7.00
10	Av.*	....	....	....	0.58	57.90	33.80	24.09	30.37	10.95	19.43

* This average is for the whole year 1893, and includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

town is taken from the ground and has a winter temperature of about 49°.

Only a small portion of the effluent is collected by the underdrains beneath the beds, and of this quantity all or nearly all again enters the ground and receives a second filtration before it reaches the brook, while most of the effluent passes for a long distance through the ground and appears in the form of springs at the edge of the low land near the brook. The existence of lateral filtration to such a marked degree is believed to be a very important feature of the Framingham filter-beds.

The average degree of purification of the applied sewage in 1893, as indicated by the albuminoid ammonia in the analyses, is as follows: —

	Per Cent. of Organic Matter Removed (Albuminoid Ammonia).
Effluent at east underdrain,	97.6
" at west underdrain,	98.0
" at spring,	99.6

Sewage from Framingham.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Iron.		Hardness.	
	Albuminoid.											
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.	Unfiltered.	Filtered.		
2.0000	.3400	.1640	.1760	4.86	.0000	.0000	4.0922	2.6860	.0900	.0500	-	1
1.6000	.3700	.1840	.1860	5.20	.0100	.0000	5.0560	2.2910	.0850	.0270	-	2
2.7200	.2000	.1140	.0860	5.40	.0000	.0000	3.1200	2.8080	.0400	.0400	5.1	3
2.8800	.3280	.2140	.1140	6.80	.0050	.0000	1.5580	1.1480	.2400	.1240	5.9	4
1.6000	.2620	.1900	.0720	8.00	.0050	.0000	3.6855	2.9160	.1160	.1000	5.1	5
2.2400	.4380	.2240	.2140	6.75	.0000	.0000	6.2800	3.1200	.1200	.0520	5.1	6
1.9840	.3940	.3100	.0840	4.70	.0050	.0000	4.3575	2.1165	.0960	.0520	5.3	7
4.0000	.5840	.3900	.1940	5.80	.0050	.0000	21.3150	2.9580	.3800	.2300	4.7	8
2.0800	.3440	.2700	.0740	5.39	.0000	.0250	4.1440	3.0640	.0700	.0560	6.1	9
2.0233	.4006	.2152	.1854	5.22	.0135	.0115	-	-	.1290	.0720	5.8	10

Odor, offensive. — The sewage was collected as it flowed out upon the filter-beds.

Chemical Examination of Effluent from the East

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.					
1	10809	Aug. 15	Slight.	Very slight.	0.02	Distinctly disagreeable.	Distinctly disagreeable.
2	10926	Aug. 30	Distinct.	Slight, white.	0.02	Distinctly musty.	Very faint or none.
3	11007	Sept. 11	None.	Slight.	0.00	None.	None
4	11083	Sept. 25	Very slight.	Cons.	0.00	Distinctly musty.	Very faintly musty.
5	11186	Oct. 12	Distinct, milky.	Slight.	0.05	Offensive.	Decidedly musty.
6	11285	Nov. 1	Distinct, milky.	Slight.	0.05	Decidedly musty.	Decidedly musty.
7	11324	Nov. 10	Very slight.	Slight, white.	0.00	Very faintly musty.	Distinctly musty.
8	11416	Nov. 29	Very slight.	Very slight.	0.02	Very faintly musty.	Decidedly musty.
9	11493	Dec. 13	Slight.	Very slight.	0.00	None.	Very faint or none.
10	Av.*	....	....	....	0.03	....	....

* The average given here includes the results of analyses made during the earlier part of the year and printed in the preceding annual report. No analyses were made in January or February.

Chemical Examination of Effluent from the West

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.*					
1	10808	Aug. 15	Very slight.	Slight.	0.03	None.	Faintly musty.
2	10925	Aug. 30	Very slight.	Very slight.	0.02	None.	Very faintly mouldy.
3	11008	Sept. 11	Very slight.	Slight.	0.00	None.	Distinct.
4	11082	Sept. 25	None.	Considerable, yellowish.	0.02	Faintly musty.	Distinctly sweetish.
5	11185	Oct. 12	None.	Very slight.	0.03	None.	Faintly musty.
6	11284	Nov. 1	None.	Slight.	0.02	None.	Distinctly musty.
7	11323	Nov. 10	Very slight.	Slight, yellowish.	0.00	Very faint or none.	Distinctly musty.
8	11415	Nov. 29	None.	Very slight.	0.00	None.	Distinctly musty.
9	11492	Dec. 13	None.	Slight, earthy.	0.00	None.	Very faint or none.
10	Av.*	....	....	....	0.04	....	....

* This average is for the whole year 1893, and includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

Underdrain at the Framingham Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
35.50	.0720	.0060	4.89	2.4000	.0120	.1501	6.2	.0100	1
27.50	.0640	.0040	3.80	1.5000	.0080	.1659	5.4	.0120	2
16.70	.0280	.0060	2.58	1.3000	.0070	.1716	3.9	.0400	3
19.10	.0560	.0060	3.89	1.0000	.0010	.0738	3.6	.0050	4
29.70	.1480	.0270	5.45	1.2000	.0090	.3442	8.1	.0200	5
28.40	.1820	.0110	5.01	1.0000	.0090	.3080	7.1	.0120	6
29.10	.0400	.0040	5.22	1.4000	.0060	.1826	6.4	.0040	7
26.30	.0600	.0040	3.80	1.7000	.0120	.1914	6.0	.0000	8
28.80	.1120	.0040	4.07	1.8000	.0050	.1504	6.0	.0200	9
24.70	.1786	.0095	3.85	1.2202	.0074	-	5.6	.0114	10

The samples were collected from the underdrain at its outlet.

Underdrain at the Framingham Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
29.80	.0480	.0030	4.00	1.6000	.0100	.1422	7.6	.0080	1
27.10	.0520	.0050	4.17	1.6000	.0040	.1106	6.1	.0150	2
28.70	.0320	.0030	3.93	1.7000	.0030	.1014	7.3	.0100	3
28.00	.0600	.0150	3.79	1.4000	.0050	.0943	5.9	.0100	4
25.60	.0160	.0030	3.62	1.8000	.0010	.1417	5.1	.0060	5
24.90	.0280	.0050	3.58	1.0500	.0060	.1320	5.1	.0040	6
24.70	.0320	.0040	3.97	1.2000	.0040	.1618	5.4	.0040	7
26.00	.0400	.0040	3.46	1.1000	.0050	.1696	5.1	.0180	8
26.10	.0560	.0040	3.63	1.6000	.0030	.1584	5.6	.0140	9
23.55	.1071	.0080	3.64	1.0360	.0045	-	5.3	.0098	10

The samples were collected from the underdrain at its outlet.

Chemical Examination of Water from a Spring near Bannister

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.					
1	10810	Aug. 15	None.	None.	0.0	None.	None.
2	10927	Aug. 30	None.	Very slight.	0.0	None.	None.
3	11009	Sept. 11	None.	None.	0.0	None.	None.
4	11084	Sept. 25	None.	Slight.	0.0	None.	None.
5	11187	Oct. 12	None.	Very slight.	0.0	None.	None.
6	11286	Nov. 1	None.	None.	0.0	None.	None.
7	11325	Nov. 10	None.	None.	0.0	None.	None.
8	11417	Nov. 29	None.	None.	0.0	None.	None.
9	11494	Dec. 13	None.	None.	0.0	None.	None.
10	Av.*	....	....	....	0.0	....	....

* The average given here includes the results of analyses made during the earlier part of

Chemical Examination of Water from Bannister Brook below the Framingham Filter-beds.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
10001	Feb. 13	Slight.	Cons., brown.	1.80	5.90	3.05	.0040	.0294	.0252	.0042	0.35	.0250	.0001	1.4819	1.7
11010	Sept. 11	Distinct.	Slight.	0.70	8.75	3.05	.0012	.0160	.0122	.0038	1.38	.1200	.0002	0.5148	3.8
11085	Sept. 25	Slight.	Slight.	0.52	8.50	1.90	.0014	.0162	.0128	.0034	1.60	.1000	.0003	0.4182	2.5
11188	Oct. 12	Slight, clayey.	V. slight.	0.55	7.75	2.20	.0030	.0156	.0122	.0034	1.16	.0280	.0010	0.4090	3.5
11287	Nov. 1	Slight.	Slight.	1.50	8.25	2.85	.0026	.0282	.0262	.0020	0.96	.0230	.0004	1.1480	2.5
11326	Nov. 10	Distinct, clayey.	V. slight.	1.40	7.35	2.65	.0026	.0270	.0250	.0020	0.97	.0450	.0003	1.1495	2.5
11418	Nov. 29	Slight.	Slight.	0.95	6.55	2.60	.0018	.0450	.0264	.0186	0.86	.0380	.0001	1.0831	2.5
Av.	....	....	....	1.15	7.37	2.67	.0026	.0259	.0207	.0052	0.96	.0505	.0003	0.9608	2.5

Odor, distinctly vegetable, rarely mouldy. On heating the odor is generally stronger and frequently mouldy or unpleasant. —— The samples were collected from the brook at the first road crossing below the sewage field.

Brook, which receives Effluent from the Framingham Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	
	Free.	Albuminoid.		Nitrates.	Nitrites.				
14.30	.0000	.0010	2.77	.4500	.0000	.0276	3.4	.0050	1
14.10	.0006	.0022	2.80	.7000	.0000	.0553	2.9	.0000	2
13.50	.0000	.0000	2.66	.7000	.0000	.0078	4.2	.0000	3
13.45	.0000	.0016	2.72	.5000	.0000	.0410	3.6	.0025	4
14.70	.0004	.0004	2.81	.5250	.0000	.0445	3.9	.0040	5
15.50	.0000	.0000	2.93	.5500	.0001	.0400	4.4	.0000	6
14.25	.0000	.0008	3.17	.5000	.0000	.0996	4.0	.0000	7
14.30	.0000	.0012	2.54	.6000	.0000	.0870	3.9	.0000	8
14.00	.0000	.0010	2.63	.5800	.0000	.0432	4.6	.0050	9
13.45	.0001	.0014	2.76	.5095	.0000	-	3.6	.0030	10

the year and printed in the preceding annual report. No analyses were made in January.

Sewage Disposal at Gardner.

The Gardner sewerage system was put in operation about Aug. 1, 1891. At the end of 1893 there were 161 connections with the sewers, 120 of which were from dwelling-houses and the remainder from factories, business blocks, hotels and public buildings. The population of the town in 1890 was 8,424. With the exception of roof-water, used for flushing purposes, from a limited number of buildings at the upper ends of the sewers, surface water is excluded. The quantity of sewage is not definitely known, but it is probably not far from 200,000 gallons per day in dry weather.

The tract purchased by the town for the disposal of the sewage contains 16.9 acres. Much of the material upon this tract was found to be too fine for the filtration of sewage, and, as a result, the filter-beds are almost wholly artificial, being formed of the porous sand and gravel from a ridge upon this tract. There are twelve thoroughly underdrained filter-beds for the disposal of sewage, having a total area of 1.39 acres, two supplementary beds which are less porous and not underdrained, having a total area of 0.37 acre, and two other small underdrained beds, containing together 0.14 acre. One of these

small beds is used to receive the sludge from the sludge tank, and the other to receive the discharge from a blow-off located at the lowest point in the pipe leading from the town, which, for the last 1,050 feet of its length where it crosses the valley of Pond Brook, is an inverted siphon. This bed was not used in 1893, however, because it has been found that if clogging occurs the sewage backs up in the pipe until sufficient head is obtained to remove the obstruction. The material of the filter-beds has an effective size of 0.10 to 0.24 millimeter, which is somewhat coarser than at Marlborough but much finer than at Framingham. The underdrains beneath the beds are generally twenty feet apart and at a depth of from four to five feet below the surface of the beds.

The sewage, when it reaches the disposal area, first passes through duplicate separating tanks having a total capacity of about 10,000 gallons, and overflows through wooden troughs upon the disposal area, as described in the annual report of the Board for 1892, page 580.

It has been the custom, except during the winter months, to apply sewage to one-half of the beds one day and the other half the next, and once in ten days or two weeks to remove one-eighth to one-quarter inch of scum and clogged sand, and afterward to rake to a depth of about 1.5 inches to loosen the material. Below this depth the material is compact to a depth of several inches.

Chemical Examination of

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
			Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1893.									
1	10795	Aug. 14	Thick.	Heavy, dark.	0.90	64.50	45.30	19.20	32.20	17.30	14.90
2	10920	Aug. 30	Decided, milky.	Cons.	0.50	28.40	19.10	9.30	15.40	7.40	8.00
3	11002	Sept. 11	Decided, thick.	Heavy.	0.50	60.10	25.80	34.30	41.10	13.60	27.50
4	11097	Sept. 27	Decided.	Heavy, gray.	0.70	32.80	21.80	11.00	18.00	10.00	8.00
5	11180	Oct. 12	Decided.	Heavy, gray.	1.20	46.40	25.40	21.00	29.20	11.60	17.60
6	11268	Oct. 30	Decided.	Heavy, gray.	1.20	36.60	24.00	12.60	19.00	9.00	10.00
7	11334	Nov. 14	Decided.	Heavy, gray.	0.60	29.20	18.40	10.80	13.60	7.00	6.60
8	11410	Nov. 28	Decided.	Heavy, gray.	0.60	35.80	20.40	15.40	16.40	8.00	8.40
9	11487	Dec. 13	Very thick.	Heavy.	0.70	43.20	20.80	22.40	30.00	10.20	19.80
10	11556	Dec. 27	Thick.	Cons., white.	0.60	28.80	23.20	5.60	17.80	12.20	5.60
11	Av.*	....	....	....	0.61	33.35	20.90	12.45	19.01	9.23	9.79

* This average is for the whole year 1893, and includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

The results obtained at Gardner have been satisfactory in the summer, but, as stated in the last annual report, in order to obtain these results it has been necessary to attend carefully to the distribution of the sewage upon the different beds, and to remove at frequent intervals the scum which forms upon them. During cold weather when the removal of this scum is prevented by snow and ice upon the beds, it has not been found practicable to filter the sewage upon the small area provided, and a portion of it has overflowed into the brook. In December, 1893, the surfaces of the filter-beds remained smooth, and were unprepared by ridging or otherwise for use in cold weather, and during the latter part of the month the sewage froze to the surfaces of some of the beds. The remaining beds were used beyond their capacity and remained constantly covered with sewage, thereby making the filtration continuous, while a considerable quantity of sewage overflowed into the brook. The effluent of the portion of the sewage filtered through the beds deteriorated in quality when cold weather began.

The analyses of sewage and effluent from the Gardner filter-beds, from August to December, 1893, are given in the following table. The averages of analyses for the whole year 1893 show that, of the sewage filtered, 91.1 per cent. of the organic matter (as represented by the albuminoid ammonia) was removed from the sewage by filtration.

Sewage from Gardner.

[Parts per 100,000.]

Ammonia.					Nitrogen as		Oxygen Consumed.		Iron.			
	Albuminoid.											
Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Hardness.	
1.9200	.8260	.5160	.3100	10.77	.0000	.0000	8.4688	3.9105	-	-	-	1
1.7600	.4380	.2220	.2160	3.20	.0000	.0000	4.0132	1.8960	.0750	.0330	-	2
3.2000	.6640	.3200	.3440	2.97	.0000	.0010	4.9520	2.5740	.1350	.0400	2.4	3
2.5600	.7080	.3620	.3460	3.40	.0050	.0010	4.3870	1.9680	.0440	.0200	4.0	4
2.8800	.7420	.4000	.3420	6.08	.0050	.0000	4.7790	2.3490	.1640	.0200	6.6	5
1.9200	.4700	.2260	.2440	3.22	.0000	.0000	6.3075	3.9150	.9000	.0280	3.9	6
2.0240	.4740	.2380	.2360	3.43	.0000	.0000	4.3160	2.7390	.0800	.0300	3.5	7
2.2400	.5800	.2920	.2880	4.96	.0050	.0400	5.7190	3.3110	.2520	.0400	3.8	8
2.3680	.6240	.3220	.3020	3.00	.0250	.0100	5.0400	3.4000	.0640	.0240	3.6	9
1.5680	.2520	.1540	.0980	2.90	.2000	.0200	2.1175	1.8095	.0300	.0140	3.8	10
1.8767	.4769	.2577	.2192	3.48	.0212	.0059	-	-	.1142	.0262	3.6	11

Odor, offensive.——The sewage was collected as it flowed upon the beds.

Chemical Examination of Effluent from the

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.*					
1	10,796	Aug. 14	Slight, milky.	Slight, white.	0.12	Decidedly disagreeable.	Offensive.
2	10,921	Aug. 30	Slight, milky.	Very slight.	0.10	Decidedly musty.	Decidedly musty.
3	11,003	Sept. 11	Slight, milky.	Very slight.	0.05	Distinctly musty.	Decidedly musty.
4	11,098	Sept. 27	Slight, milky.	Very slight.	0.12	Decidedly musty.	Decidedly musty.
5	11,181	Oct. 12	Slight, milky.	Very slight.	0.03	Offensive.	Decidedly musty.
6	11,269	Oct. 30	Very slight.	Very slight.	0.02	Decidedly musty.	Offensive.
7	11,335	Nov. 14	Very slight.	None.	0.02	Decidedly musty.	Decidedly musty.
8	11,411	Nov. 28	Distinct.	Considerable, white.	0.20	Offensive.	Offensive.
9	11,488	Dec. 13	Slight, milky.	Slight.	0.12	Distinctly musty.	Distinctly musty.
10	11,557	Dec. 27	Distinct, milky.	Slight.	0.10	Decidedly musty.	Offensive.
11	Av.*	....	....	... .	0.15	....	....

* The average given here includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

Chemical Examination of Water from Pond Brook above the Gardner Filter-beds.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.
	1893.														
11004	Sept. 11	Slight.	Slight.	0.18	19.70	5.80	.0032	.0180	.0162	.0018	4.99	.0650	.0020	.3198	9.1
11099	Sept. 27	Slight, milky.	Slight.	0.18	19.65	3.20	.0056	.0182	.0166	.0016	5.44	.0400	.0020	.4510	9.3
11182	Oct. 12	Slight, milky.	Slight.	0.18	24.90	4.80	.0114	.0246	.0214	.0032	6.37	.0280	.0023	.4212	11.5
11270	Oct. 30	Distinct, milky.	V. slight.	0.45	14.30	3.90	.0360	.0250	.0130	.0120	2.77	.0800	.0050	.5916	4.6
11336	Nov. 14	Slight.	Cons.	0.18	10.50	3.20	.0310	.0180	.0130	.0050	2.28	.0800	.0010	.3486	4.2
11412	Nov. 28	Decided.	Heavy, gray.	0.50	11.50	3.80	.0338	.0550	.0312	.0238	1.98	.1250	.0020	2.4080	3.6
11489	Dec. 13	Distinct, milky.	Cons., brown.	0.15	12.70	3.00	.0640	.0270	.0210	.0060	2.41	.1700	.0010	.3184	4.2
Av.	....	....	....	0.26	16.18	3.96	.0264	.0265	.0189	.0076	3.75	.0840	.0022	.6941	6.6

Iron, .0299. Odor generally distinctly musty, occasionally offensive.—— The samples were collected from the brook above the point where it is crossed by the main sewer leading to the filter-beds.

Main Underdrain of the Gardner Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.		Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.	Iron.	
	Free.	Albuminoid		Nitrates.	Nitrites.				
21.90	.4400	.0310	1.97	2.4000	.1600	.5767	5.3	.0600	1
17.00	.1200	.0230	2.00	1.5000	.0240	.2765	4.7	.0100	2
18.80	.0960	.0240	1.61	1.4000	.0100	.2808	6.3	.0050	3
13.50	.0920	.0150	1.65	1.0000	.0020	.2624	4.4	.0080	4
36.10	.1060	.0180	2.41	3.9200	.0800	.3726	11.9	.0100	5
14.20	.2240	.0120	2.17	0.8500	.0600	.3741	3.8	.0020	6
14.10	.0880	.0090	2.42	0.8200	.0100	.2739	3.5	.0100	7
13.40	.6060	.0660	2.43	0.5500	.0500	.6794	2.7	.0120	8
11.90	.8000	.0360	2.01	0 3200	.0020	.3720	2.6	.0060	9
11.00	.8400	.0290	1.96	0.2000	.0020	.3927	3.0	.0050	10
14.70	.4628	.0423	2.08	0.7783	.0257	-	4.1	.0266	11

The samples were collected from the main underdrain at the point where it discharges into the brook.

Chemical Examination of Water from Pond Brook below the Gardner Filter-beds.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
11005	Sept. 11	Slight.	Slight.	0.38	20.70	7.10	.0126	.0204	.0182	.0022	4.25	.2000	.0030	.3003	8.9
11100	Sept. 27	Slight, milky.	Cons., floc.	0.18	17.75	3.25	.0130	.0118	.0114	.0004	4.63	.2000	.0025	.4059	8.4
11183	Oct. 12	Slight, milky.	Slight.	0.15	39.00	19.50	.0360	.0140	.0090	.0050	6.39	.2000	.0045	.4698	11.6
11271	Oct. 30	V. slight, milky.	V. slight.	0.45	13.20	3.60	.0560	.0130	.0090	.0040	2.64	.2300	.0120	.6177	4.4
11337	Nov. 14	Slight.	Cons.	0.18	10.60	3.50	.0420	.0190	.0130	.0060	2.27	.1300	.0020	.3735	4.2
11413	Nov. 28	Decided.	Heavy, gray.	0.50	10.70	3.60	.0816	.0358	.0252	.0106	1.84	.1850	.0040	1.9780	3.2
11490	Dec. 13	Slight, milky.	Slight.	0.12	12.30	3.00	.1440	.0240	.0200	.0040	2.18	.2000	.0010	.3536	4.2
Av.	....	....	....	0.28	17.75	6.08	.0550	.0197	.0151	.0046	3.46	.1850	.0041	.6427	6.4

Iron, .0222. Odor generally distinctly musty, occasionally offensive. —— The samples were collected from the brook below the filter-beds, and below the points where effluent from the filter-beds enters the stream.

Sewage Disposal at Lenox.

The village of Lenox is situated upon high land, from which the ground slopes to the west, south and east. The first attempt at sewage purification was made in 1876 at a small field upon the westerly slope of the hill. In 1881 the sewage of a few houses on the southerly slope of the hill was conveyed to a small tract of land at the foot of the hill in the town of Stockbridge and there disposed of. In 1888 the principal sewerage system of the town was completed, and by it the sewage is conveyed to a disposal field about two miles east of the village and near the Housatonic River.

This system diverted much of the sewage which formerly went to the small field on the westerly slope of the hill, but, notwithstanding the reduced quantity of sewage going to this field and the small quantity going to the southerly field, the neighboring land owners objected to the use of these areas for sewage disposal, and in December, 1893, works were completed for collecting the sewage of the westerly and southerly slopes at a pumping station west of the village and for pumping it into the main system of sewers leading to the easterly field, which will be the only one in use after the pumping station is operated.

The sewers of Lenox are pipe sewers, and storm-water is excluded from them, except a small quantity of roof-water, which is admitted for flushing purposes. There are said to be about 1,000 persons connected with the system ordinarily, but during the summer season the number is more than doubled.

The main pipe leading from the village to the easterly disposal field is twelve inches in diameter, and ends at a settling tank on the upper portion of the hillside, about 800 feet from the Housatonic River. The tank is of masonry, and has two separate compartments. There are two overflow pipes, one discharging into a pipe connecting with the sub-surface disposal system and the other with a pipe which has a direct connection with the river. There is also a pipe at the bottom of the tank through which the sludge can be run out whenever the tank needs cleaning.

The sewage is disposed of beneath the surface by turning it into stone drains, which are long, nearly-level trenches, filled with stone up to within a short distance of the surface, and above the stone with earth and loam. In addition to the stone the trench contains a six-inch Akron pipe, with open joints, through which the sewage

from the settling tank is conveyed to the drains. These drains vary in length from 200 to 800 feet.

Beneath these stone drains are underdrains, about thirty feet apart, running down hill toward the river. The underdrains are laid with tight joints where they pass beneath the stone drains and with open joints between the drains.

The material of the disposal field is compact and nearly impervious, so that only a portion of the sewage will filter through the ground and the remainder flows out from the stone drains upon the surface through relief pipes which have been laid at their farther ends, or passes off into the river through one of the overflow pipes at the settling tank.

In the following table will be found analyses of sewage and effluent taken from different points of the Lenox system. The sewage is very dilute, owing to the large amount of ground water entering the sewers. It may be noticed, by reference to the table, that the second and third samples, taken from the settling tank after some precipitation had taken place and from the ends of the stone drains, are much less impure than the first sample, which was collected from the main sewer. There was, doubtless, some improvement in quality caused by the passage of the sewage through the settling tank and through the drains, but the bulk of the difference is probably due to the fact that the sewage from the main sewer represented the day sewage, while the samples from the tank and drains represented to a greater extent the night flow, the larger proportion of which is ground water.

Chemical Examination of Sewage and Effluent from the Lenox Sewage Purification Works.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Odor.		Residue on Evaporation.					
							Total Residue.			Loss on Ignition.		
		Turbidity.	Sediment.	Color.	Cold.	Hot.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
	1893.											
11499	Dec. 11	Decided.	Heavy, gray.	0.28	Offensive.	Offensive.	38.80	23.00	15.80	20.20	7.20	13.00
11500	Dec. 11	Distinct.	Cons., gray.	0.15	Offensive.	Offensive.	21.00	19.20	1.80	4.80	3.00	1.80
11501	Dec. 11	Distinct.	Cons., gray.	0.15	Offensive.	Decidedly musty.	20.20	19.60	0.60	4.20	4.20	0.00
11502	Dec. 11	V. slight.	Cons., dark.	0.02	V. faintly musty.	V. faint or none.	30.80	29.40	1.40	5.60	5.00	0.60

Chemical Examination of Sewage and Effluent from the Lenox Sewage Purification Works — Concluded.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Hardness.	Iron.	
	Albuminoid.										
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.		Unfiltered.	Filtered.
1.2000	.2240	.0980	.1260	1.39	.0050	.0000	3.2000	1.0800	11.0	.1600	.0160
.6400	.0700	.0380	.0370	0.83	.0000	.0000	.7200	.4800	11.3	.0140	.0100
.7200	.0590	.0330	.0260	0.95	.0000	.0010	.6800	.4800	11.9	.0200	.0100
.0240	.0110	.0100	.0010	1.36	.3800	.0030	.3840	.3360	15.9	.2000	.0000

The first sample was collected from the sewer which conveys sewage from the town; the second, from the main settling tank; the third, from the ends of the sub-surface pipes in the stone drains; the last, from the outlet of the underdrains.

Sewage Disposal at Marlborough.

The sewerage system of the city of Marlborough (population in 1890, 13,805) was completed late in 1891, and at the end of 1893 there were about 800 connections, including those from all of the larger places, such as hotels, factories, etc. The total length of sewers was 21.58 miles. The so-called separate system was adopted, but no underdrains were laid beneath the sewers and a large amount of ground water enters them at certain seasons of the year.

As the sewage arrives at the disposal field it passes through separating tanks and screens before passing into the distributing pipes. The tanks are built in duplicate, to facilitate cleaning, and, including the portions where the screens are situated, are each about twenty-five feet long, six and one-half feet wide and six feet deep. The screens are of wire and have a one-inch mesh. The elevation of the tanks above the sandy land is such that it was feasible to prepare beds upon which the sludge deposited in the tanks could be turned by gravity.

Thirteen sewage beds, with a total area of 9.6 acres, and six sludge beds, with a total area of 1.7 acres, have been prepared for the disposal of the sewage and the sludge. The material of the beds is finer than that of Framingham and Gardner, and has an

effective size of 0.12 to 0.14 millimeter. The area has a moderate slope toward a small brook, and is from seven to twenty-two feet above it. The beds are thoroughly underdrained by means of parallel lines of four-inch pipes, laid with open joints fifty feet apart and about six feet beneath the surface. All of these drains discharge into the brook before mentioned.

The sewage is ordinary city sewage, varying in strength from time to time with the amount of ground water which enters the sewers. The average quantity is not definitely known, but it was probably in the neighborhood of 400,000 gallons per day during 1893.

Previous to December, 1893, it is said that the beds were generally flooded in turn for twenty-four hours, but that, beginning with this month, they were flooded in turn as before, but for only half a day at a time, and the results obtained from this treatment show, apparently, an improvement. The beds were harrowed twice during the year, about the first of May and the first of November, with a wheel-harrow, to a depth of four to six inches. In November no leveller was attached to the harrow, and the surface was left in alternate ridges and furrows. The grass and weeds were cut several times during the summer, and in the fall several beds, where the weeds grew more luxuriantly, were ploughed before harrowing. A considerable portion of the sludge in the sewage passes through the separating tanks and in time forms a thick scum upon the surfaces of the filter-beds. This scum was removed at irregular intervals during the warmer months, but not during the winter. As a general rule the scum was removed before the surfaces were ploughed or harrowed.

With the aid of the furrowed surfaces and the application of smaller doses the filters disposed of the sewage during the winter months with satisfactory results. At times there has been considerable odor from the sludge beds, but as the beds are a long distance from any road or habitation this has not been a source of complaint.

It has not been the custom to employ a man constantly in caring for the beds, but to employ a man living in the neighborhood to attend to changing the flow of sewage from bed to bed, and to remove the scum from the surfaces of the beds, paying him by the hour for the time spent on the work. The cost of all work done on the beds during the year 1893 amounted to $497.19.

The averages of the analyses for the whole year 1893 indicate that 94.2 per cent. of the organic matter, as represented by the albuminoid ammonia, was removed from the sewage applied.

Chemical Examination of

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Residue on Evaporation. Total Residue. Total.	Total Residue. Dissolved.	Total Residue. Suspended.	Loss on Ignition. Total.	Loss on Ignition. Dissolved.	Loss on Ignition. Suspended.
		1898.									
1	10844	Aug. 15	Thick, opaque.	V. heavy, dark.	0.50	230.40	44.40	186.00	162.80	20.00	142.80
2	10933	Aug. 30	Thick, milky.	Heavy, dark.	0.90	86.70	48.30	38.40	45.90	17.50	28.40
3	11058	Sept. 18	Thick, milky.	Heavy, dark.	0.70	95.30	55.90	39.40	51.60	17.70	33.90
4	11101	Sept. 26	Decided.	Heavy, dark.	-	81.00	47.80	33.20	41.40	18.00	23.40
5	11191	Oct. 12	Thick.	Heavy, dark.	-	70.00	36.80	33.20	39.80	17.20	22.60
6	11262	Oct. 27	Decided.	V. heavy, dark.	-	298.00	33.00	265.00	179.40	9.80	169.60
7	11339	Nov. 15	Decided, milky.	Cons., heavy.	0.90	108.80	82.60	26.20	35.20	16.20	19.00
8	11425	Nov. 29	Distinct.	Cons., brown.	0.20	24.40	23.60	0.80	5.60	5.20	0.40
9	11483	Dec. 12	Thick.	V. heavy, brown.	0.70	66.60	39.40	27.20	33.60	11.00	22.60
10	11548	Dec. 26	Decided.	Heavy, gray.	0.50	44.80	26.40	18.40	21.00	9.00	12.00
11	Av.*	....	....	....	0.54	72.36	34.93	37.43	37.27	10.83	26.43

* This average is for the whole year 1898 and includes the results of analyses made during the earlier portion of the year and printed in the preceding annual report.

Chemical Examination of Effluent from the

[Parts per 100,000.]

	Number	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1898.					
1	10845	Aug. 15	Slight.	Slight, fibrous.	0.05	Distinctly musty.	Decidedly musty.
2	10846	Aug. 15	Distinct.	Slight, rusty.	0.05	Distinctly musty.	Decidedly musty.
3	10934	Aug. 30	Decided.	Cons., white.	0.25	Offensive.	Decidedly musty.
4	10935	Aug. 30	None.	None.	0.00	Offensive.	Faintly musty.
5	11059	Sept. 18	Decided, milky.	Heavy, rusty.	0.50	Offensive.	Offensive.
6	11060	Sept. 18	Decided, milky.	Slight.	0.10	Offensive.	Offensive.
7	11102	Sept. 26	Decided, milky.	Cons., floc. and fibrous.	0.15	Offensive.	Decidedly musty and offensive.
8	11103	Sept. 26	Very slight.	Very slight.	0.00	Distinctly musty.	Very faint or none.
9	11192	Oct. 12	Distinct.	Cons., gray.	0.50	Offensive.	Offensive.
10	11193	Oct. 12	Very slight.	Very slight.	0.02	Offensive.	Offensive.

Sewage from Marlborough.

[Parts per 100,000.]

Ammonia.					Nitrogen as		Oxygen Consumed.		Iron.			
	Albuminoid.											
Free.	Total.	Dissolved.	Suspended.	Chlorine.	Nitrates.	Nitrites.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	Hardness.	
3.2000	1.6000	.2200	1.3800	7.40	.0050	.0000	14.2740	3.7908	1.3000	.0700	-	1
3.2000	.7260	.2340	.4920	10.00	.0050	.0000	6.7545	3.2785	.1800	.0850	-	2
2.8800	1.0460	.4380	.6080	12.00	.0050	.0000	8.6100	4.7150	.5300	.0750	5.2	3
2.0000	1.1680	.4300	.7380	8.40	.0050	.0000	9.1020	4.7970	.2200	.0740	6.3	4
5.0000	.7200	.3140	.4060	9.00	.0050	.0000	7.6140	3.3210	.3600	.1400	6.6	5
1.0800	1.7060	.1800	1.5260	4.60	.0000	.0000	22.3590	3.2190	1.7680	.3200	11.6	6
2.0800	.8760	.4340	.4420	32.95	.0000	.0000	7.7605	4.3575	.2100	.1400	7.6	7
.2320	.0580	.0350	.0230	3.59	.9000	.0300	1.5660	1.1745	.1120	.0600	9.6	8
4.1600	.9740	.3580	.6160	8.20	.0100	.0000	6.6400	3.0000	.2740	.1160	7.9	9
1.3440	.5620	.1920	.3700	5.21	.2000	.1600	3.5700	1.5960	.1500	.0120	8.4	10
2.0140	.6136	.2164	.3972	7.36	.1125	.0286	-	-	.3163	.0754	7.3	11

Odor, offensive.——The samples were collected from the separating tanks and represent the sewage after a portion of the suspended matter had been separated from it.

Underdrains of the Marlborough Filter-beds.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia.			Nitrogen as					
	Free.	Albuminoid.	Chlorine.	Nitrates.	Nitrites.	Oxygen Consumed.	Hardness.	Iron.	
37.20	.3920	.0130	6.13	1.6250	.0086	.2705	7.6	.0280	1
37.90	.4000	.0200	5.92	1.7500	.0125	.2239	11.0	.0330	2
32.40	.8400	.0900	7.45	.8000	.0760	.7742	7.1	.0250	3
34.00	.2480	.0080	5.82	1.6000	.0300	.1698	9.4	.0150	4
46.60	.9600	.0460	6.92	2.2000	.0200	.3526	10.8	1.0500	5
47.00	.7000	.0540	7.60	2.4000	.0170	.5166	11.5	.0400	6
37.70	.8000	.0690	7.37	2.0000	.0240	.6232	8.4	.0250	7
22.10	.0240	.0020	4.07	1.6000	.0020	.2173	6.3	.0000	8
28.70	1.6000	.2060	7.20	.0300	.1200	1.3648	6.4	.0500	9
38.00	.4200	.0220	7.97	2.0000	.0200	.2227	8.3	.0300	10

Chemical Examination of Effluent from the

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
1	11263	Oct. 27	Decided.	Cons., rusty.	0.40	Offensive.	Offensive.
2	11264	Oct. 27	Distinct.	Cons., light.	0.12	Offensive.	Offensive.
3	11340	Nov. 15	Distinct, milky.	Slight.	0.15	Offensive.	Offensive.
4	11341	Nov. 15	Distinct, milky.	Cons., fibrous.	0.08	Offensive.	Offensive.
5	11426	Nov. 29	Distinct, milky.	Slight.	0.12	Offensive.	Offensive.
6	11427	Nov. 29	None.	None.	0.00	Offensive.	Offensive.
7	11484	Dec. 12	Slight, milky.	Slight.	0.07	Faintly musty.	Decidedly musty.
8	11485	Dec. 12	Very slight.	Very slight.	0.05	Distinctly musty.	Decidedly musty and disagreeable.
9	11549	Dec. 26	None.	Very slight.	0.00	Distinctly musty.	Decidedly musty.
10	11550	Dec. 26	Very slight.	Slight.	0.03	Decidedly musty.	Decidedly musty.
11	Av.*	....	....	....	0.91	....	....

* The average given here includes the results of analyses made during the earlier part of the year and printed in the preceding annual report.

Chemioal Examination of Water from the Brook into which the

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance. Turbidity.	Appearance. Sediment.	Appearance. Color.	Odor. Cold.	Odor. Hot.
		1893.					
1	11061	Sept. 18	Very slight.	Cons., rusty.	0.28	Faintly vegetable.	Faintly vegetable.
2	11062	Sept. 18	Very slight.	Cons., brown.	0.20	Decidedly disagreeable.	Decidedly musty.
3	11104	Sept. 26	Slight.	Slight.	0.08	Decidedly musty.	Decidedly musty.
4	11194	Oct. 12	Very slight.	Slight, earthy.	0.10	Distinctly musty.	Decidedly musty.
5	11265	Oct. 27	None.	None.	0.12	Decidedly musty.	Offensive.
6	11342	Nov. 15	Very slight.	Slight.	0.10	Decidedly musty.	Decidedly musty.
7	11428	Nov. 29	Very slight.	Slight, brown.	0.45	Distinctly musty.	Decidedly musty.
8	11486	Dec. 12	Very slight.	Slight.	0.18	Faintly mouldy.	Distinctly mouldy.
9	11551	Dec. 26	Slight.	Considerable.	0.55	Faintly vegetable.	Distinctly veg'ble.
10	Av.*	....	....	....	0.22	....	....

* Sample No. 11061 is omitted from the average.

Underdrains of the Marlborough Filter-beds — Concluded.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.	
36.80	.8000	.0190	7.45	1.5000	.0200	.5133	9.1	.1500	1
29.50	.9000	.0360	6.34	1.1000	.0180	.4959	7.1	.0160	2
36.00	.9280	.0650	6.60	1.5000	.0200	.7719	9.0	.0400	3
32.50	1.0000	.0960	4.55	.7000	.0060	.8756	8.0	.0420	4
32.40	.8000	.0580	5.60	1.6000	.0110	.6351	7.9	.0050	5
33.50	.5600	.0220	6.56	1.5000	.0080	.2958	9.3	.0100	6
23.90	.8800	.0280	4.80	.8200	.0050	.3344	6.1	.0160	7
31.00	.6720	.0260	5.60	1.3000	.0080	.2464	8.3	.0060	8
31.00	.2800	.0140	5.23	1.0000	.0120	.1932	8.0	.0070	9
32.10	.4400	.0140	5.77	1.2500	.0100	.2268	7.9	.0070	10
28.92	.5931	.0353	5.08	1.0130	.0234	-	7.7	.0405	11

The samples were collected from the underdrains, generally from those beneath the beds to which sewage was being applied at the time.

Effluent from the Marlborough Sewage Filter-beds is discharged.

[Parts per 100,000.]

Residue on Evaporation. Total.	Residue on Evaporation. Loss on Ignition.	Ammonia. Free.	Ammonia. Albuminoid. Total.	Ammonia. Albuminoid. Dissolved.	Ammonia. Albuminoid. Suspended.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	
4.30	1.30	.0000	.0146	.0108	.0038	0.31	.0070	.0000	.2132	1.7	1
33.70	12.65	.5040	.0340	.0220	.0120	6.19	.9000	.0096	.8198	7.9	2
29.20	8.20	.3680	.0640	.0290	.0350	5.55	1.4000	.0540	.4756	7.4	3
26.10	6.00	.2270	.0200	.0190	.0010	4.96	1.0000	.0670	.3888	5.7	4
25.90	6.40	.3040	.0320	.0160	.0160	5.65	.9500	.0480	.4611	6.1	5
25.60	6.80	.4000	.0300	.0200	.0100	4.83	1.2500	.0230	.4150	6.4	6
18.20	5.90	.1400	.0120	.0100	.0020	2.80	1.0000	.0120	.5070	4.2	7
20.60	5.30	.2560	.0200	.0160	.0040	3.55	1.0000	.0080	.3864	5.3	8
15.00	5.40	.1600	.0210	.0160	.0050	2.21	.5500	.0040	.6804	3.9	9
24.29	7.08	.2949	.0291	.0185	.0106	4.47	1.0063	.0282	.4543	5.9	10

Iron, .0094. The first sample was collected from the brook above the filter-beds; the remaining samples from the brook below the filter-beds after it had received the effluent therefrom.

Sewage Disposal at Medfield.

A system of sewage disposal by intermittent filtration was introduced at Medfield in 1886, and was described in the Nineteenth Annual Report of the Board for the year 1887. Up to the end of 1893 connections had been made with one hotel, three houses and a large straw factory, in which, at times, as many as 900 operatives are employed. The original area of the beds was about one acre. The material is mostly coarse gravel. As the level of the ground water is about ten feet below the surface of the filter there are no underdrains. There are four beds, the surfaces of which are some-

Chemical Examination of

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.					
					Total Residue.			Loss on Ignition.		
		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
11167	1893. Oct. 11	Decided.	Heavy, brown.	0.70	31.60	27.40	4.20	9.60	7.80	1.80

Odor, offensive.—— The sewage was collected as it flowed upon the filter-beds.

Chemical Examination of Water from a Spring below

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Odor.	
			Turbidity.	Sediment.	Color.	Cold.	Hot.
1	10645	1893. July 11	Very slight.	Very slight.	0.02	None.	None.
2	10798	Aug. 14	Very slight.	Very slight.	0.08	None.	Faintly earthy.
3	11023	Sept. 13	Very slight.	Slight.	0.08	Very faint or none.	Distinctly vegetable and mouldy.
4	11168	Oct. 11	None.	Very slight.	0.03	Faintly musty.	Very faint or none.
5	11382	Nov. 23	None.	Slight.	0.01	None.	Faintly musty.
6	Av...	....	....	....	0.04	....	....

The samples were collected from the spring which is located north of the filter-beds and a little over direction of this spring.

what uneven, each of which, as a general rule, takes the sewage in turn for two days. It was found that there was considerable loam a short distance below the surface of a portion of the beds which eventually became clogged. In the summer of 1893 this loam was removed and replaced with coarse gravel, and the area of the filter increased about one-third.

No trouble has arisen from odors. In the following tables will be found analyses of the sewage, and of the effluent taken from a spring a short distance below the filter. The effluent is of excellent quality, and no deterioration is shown by the analyses when compared with those made in 1887, after the works had been in operation for a comparatively short time.

Sewage from Medfield.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Iron.		Hardness.
Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	
2.5600	.3780	.2000	.1780	1.58	.0030	.0000	2.6730	1.8630	.0400	.0300	3.0

The straw shop was not running at the time the sample was collected.

the Filtration Area of the Medfield Sewerage System.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.	
11.70	.0010	.0048	0.94	.1500	.0000	.0584	3.1	.0060	1
11.70	.0032	.0068	1.00	.2500	.0020	.1833	3.8	.0000	2
15.10	.0010	.0098	1.37	.1000	.0030	.2028	5.4	.0070	3
12.10	.0014	.0044	1.20	.1350	.0013	.1620	4.3	.0020	4
10.15	.0000	.0034	1.05	.1900	.0003	.1512	3.6	.0000	5
12.15	.0013	.0058	1.11	.1650	.0013	.1515	4.0	.0030	6

260 feet from the edge of the nearest bed. The ground where the filter-beds are located slopes in the

Sewage Disposal at Wellesley College.

Up to 1892 the greater part of the sewage from the Wellesley College buildings was disposed of by passing it through small and imperfect artificial filters of peat and gravel, but as the results obtained by this method were unsatisfactory, new works were constructed in 1892 for the treatment of the sewage from the main building and cottages near it, by intermittent filtration.

As the works were first constructed the sewage passed from the buildings through pipe sewers to a settling tank six feet in diameter, thence into an automatic flush tank thirty feet long and six feet wide, in which the sewage had a depth of twenty-six inches, and from the flush tank was discharged into two eight-inch pipes passing through the middle of a nearly level filtration area 300 feet long and 150 feet wide. Every four feet along each of the eight-inch pipes there was laid out to the edge of the area a line of three-inch pipes, with open joints, for distributing the sewage. These pipes were about twenty inches below the surface of the ground, and the joints between some of them were covered with tarred paper and all were surrounded with coarse gravel. Much of the material of the filter bed is coarse sand or gravel, but in some places there is a very fine sand.

After about three months' use the pipes were so badly clogged that it was necessary to dig them up and clean them. It was found that many of the pipes were clogged with pieces of rags and paper, and that the fine sand had filled the interstices of the coarse gravel.

Chemical Examination of

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.					
					Total Residue.			Loss on Ignition.		
		Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
11419	1892. Nov. 29	Thick, white.	V. heavy, white.	0.50	184.00	92.60	91.40	117.60	32.00	85.60

Odor, offensive. —— The sample was collected from the third

After this clogging occurred provision was made for screening the sewage so as to prevent the entrance of coarse substances into the eight-inch pipes.

In the summer of 1893 some further changes were made. Two settling tanks, each ten feet long and six feet wide, were added, and the length of the filtration area was extended to 450 feet, making the total area 1.55 acres. All of the sub-surface distributing pipes were relaid, and over the joints of the pipes, in all cases, were placed pieces of half-pipe of larger diameter. An eight-inch pipe was laid along each side of the filtration area and connected with the ends of all of the three-inch distributing pipes. Gates have been placed at the lower ends of all of the eight-inch pipes, and about once a week, usually on washing day, they have been opened with a view to flushing the entire system of pipes. The sewage used in flushing discharges upon a thin filter-bed about fifty feet square. It has been the custom to empty the settling tanks once a week, and at these times the liquid matter is discharged upon a small filter-bed constructed for this purpose, while the semi-solid portions remaining are run into carts and removed to some woods at a considerable distance from the buildings where they are disposed of by composting. There are about 500 people connected with this system. There have been no indications of clogging in the sub-surface pipes since the changes were made.

In the following tables will be found analyses of the Wellesley sewage, and of samples of water taken from a small brook, into which some of the effluent finds its way, above and below the filter-bed.

Sewage from Wellesley.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Iron.		Hardness.
	Albuminoid.										
Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.	Unfiltered.	Filtered.	
5.4000	2.8800	1.3300	1.5500	24.00	.0000	.0000	31.7550	16.0950	.1700	.1000	16.4

settling tank and before the sewage entered the flush tank.

Chemical Examination of Water from the Brook above and below the Wellesley Sewage Filtration Area.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
								Albuminoid.							
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.		Nitrates.	Nitrites.		
	1893.														
11420	Nov. 29	Slight.	Slight.	1.30	11.85	5.65	.0148	.0584	.0546	.0038	0.82	.1700	.0003	1.7139	3.8
11421	Nov. 29	Slight.	Cons., fibrous.	1.10	14.00	5.20	.0416	.0700	.0422	.0278	1.43	.4500	.0009	1.5573	4.6
11422	Nov. 29	Distinct, milky.	Cons., rusty.	1.00	10.30	3.50	.0520	.0200	.0152	.0048	1.22	.1000	.0015	0.5829	4.0

Iron, .0878. Odor of the first sample, none; of the second, faintly earthy; of the last, strong of gas liquors. On heating, the odor of the first two samples was distinctly vegetable, but the last was unchanged.——The first sample was collected from the brook above the filter-beds; the second, near the sludge bed, and the last, near the gas works, about 150 feet above the point where the brook enters Waban Lake.

Sewage Disposal at Westborough.

The construction of the sewerage system of the town of Westborough (population in 1890, 5,195) was begun in 1891, and up to the end of the year 1893 ninety-one connections had been made with the sewers, forty-three of which were from the larger places, such as business blocks, factories, etc. The main sewer leading from the town to the place of disposal passes through low wet ground, and receives a large amount of ground water.

The sewage is disposed of upon land located on the right bank of the Assabet River, in the north-westerly part of the town. About thirty-three acres were taken by the town for sewage-disposal purposes, 17.5 of which may be classed as swamp or meadow subject to flooding at times of high water, its surface being at an elevation of three feet or less above the ordinary level of the river. About six acres of the upland is at too great an elevation to be reached by gravity without grading.

The sewage is conducted to a settling tank on the disposal area. The tank is of masonry, built in two compartments, and has a total capacity of less than 1,000 gallons. Two filter beds, having a total area of a little over two acres, were prepared in 1892 by stripping off most of the loam and filling with coarse sand or gravel to depths varying from about thirty inches at the lower end to about a foot at

the other end. The material beneath the filling is a fine, compact sand almost impervious to water. The surfaces of the beds are from six to six and one-half feet above the ordinary level of the surface of the water in the Assabet River, opposite the sewage field. During the prevalence of high water in the spring the surface of the water in the river rises to about three feet above the ordinary level.

Sewage was applied to the beds in April, 1893, and it was found that the sand beneath the artificial and porous surface layer was so fine that it remained saturated and also kept the material above it saturated for weeks after the application of sewage had ceased. It is said that these beds could be made to take the whole flow of sewage for about a week by filling them to the level of the top of the embankment. On discontinuing the use of the beds in July it took eight weeks for the sewage to disappear.

To obtain material to prepare the filter beds as above described, a pit was excavated in a gravel ridge in the higher portion of the area owned by the town. Into this gravel pit, covering an area of approximately 15,000 square feet, the bottom of which is said to be six inches above the ground-water level, the sewage has been discharged from time to time, and it has been filled to the level of the bottom of the sewage carrier, or approximately six feet deep, forming a huge cesspool, the effluent from which appeared in the form of a flowing spring, on the surface of a piece of low land fifty to seventy-five feet from the edge of the excavation. During the year 1893 sewage has also been discharged from time to time on a portion of the unprepared ground and allowed to flow over its surface to find its way to the meadows.

The selectmen of the town applied to the State Board of Health, Sept. 18, 1893, stating that the former advice of the Board had not been carried out, and requesting the Board to make another examination of the present sewage-disposal works at Westborough, and advise the town farther in the matter of sewage disposal. The reply of the Board to this application may be found on page 86 of this volume.

Toward the end of the year the surfaces of the two filter beds were raised from one to two feet by the addition of more coarse sand, and two six-inch underdrains were placed beneath the beds at depths of from three to five feet beneath the surface. In addition to this work, two additional beds, each about an acre in area, were prepared between the settling tank and the river. The surfaces

of the new beds were levelled to some extent, and in each two four-inch underdrains were laid three feet below the surface at the upper ends and five feet below at the lower ends. It is said that some of the mud in the low places on the area covered by these beds was removed while preparing the beds and replaced with gravel from a knoll situated partly within the limits of the beds. There is considerable loam remaining on each bed. Sewage was distributed

Chemical Examination of Sewage from

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Residue on Evaporation.					
						Total Residue.			Loss on Ignition.		
			Turbidity.	Sediment.	Color.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.
		1893.									
1	11171	Oct. 11	Decided.	Heavy, gray.	1.20	31.00	16.40	14.60	17.00	7.80	9.20
2	11406	Nov. 28	Decided.	Cons., gray.	0.20	10.00	8.00	2.00	4.20	2.80	1.40

Odor, offensive.——The samples were collected from the

Chemical Examination of Effluent from the

[Parts per 100,000.]

	Number.	Date of Collection.	Appearance.			Odor.	
			Turbidity.	Sediment.	Color.	Cold.	Hot.
		1893.					
1	11174	Oct. 11	Distinct.	Considerable.	1.20	Very disagreeable.	Offensive.
2	11407	Nov. 28	Slight.	Very slight.	0.03	Tarry.	Offensive.
3	11408	Nov. 28	Distinct.	Cons., green.	0.50	Distinctly vegetable and mouldy.	Decidedly vegetable and grassy.
4	Av...	....	....	....	0.58	....	....

The first and last samples were collected from the spring below the gravel pit; the second

upon the two new beds from trenches along the sides and by furrows across the beds. The distribution, however, at the time the beds were examined was very uneven.

In the following table will be found analyses of samples of the sewage, of the effluent from the gravel pit collected at the spring already mentioned and of samples collected from the Assabet River above and below the disposal area.

the Westborough Sewerage System.

[Parts per 100,000.]

Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.		Iron.		Hardness.	
Free.	Albuminoid. Total.	Albuminoid. Dissolved.	Albuminoid. Suspended.		Nitrates.	Nitrites.	Unfiltered.	Filtered.	Unfiltered.	Filtered.		
1.7600	.3080	.2200	.0880	3.81	.0050	.0000	3.7665	2.7540	.1200	.0360	3.6	1
0.3840	.0720	.0500	.0220	0.73	.0350	.0050	1.6770	1.0320	.4100	.0280	3.2	2

sewer at the point where it discharges upon the filter-beds.

Beds of the Westborough Sewerage System.

[Parts per 100,000.]

Residue on Evaporation.	Ammonia. Free.	Ammonia. Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.	Hardness.	Iron.	
10.20	.0008	.0264	2.84	.0000	.0000	1.0732	2.2	.1180	1
5.70	.2000	.0220	0.86	.0400	.0040	.2322	2.3	.0000	2
9.10	.1960	.0220	2.00	.0000	.0000	.6364	2.5	.0210	3
8.33	.1323	.0235	1.90	.0133	.0013	.6473	2.3	.0463	4

sample from the underdrain of new filter-beds which had been in use but six days.

Chemical Examination of Water from the Assabet River above and below the Westborough Sewage Filter-beds.

[Parts per 100,000.]

Number.	Date of Collection.	Appearance.			Residue on Evaporation.		Ammonia.				Chlorine.	Nitrogen as		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	Color.	Total.	Loss on Ignition.	Free.	Albuminoid.				Nitrates.	Nitrites.		
								Total.	Dissolved.	Suspended.					
	1893.														
10840	Aug. 16	V. slight.	V. slight.	0.45	5.00	1.80	.0026	.0166	.0140	.0026	.23	.0030	.0000	.3996	1.3
11172	Oct. 11	V. slight.	Slight.	0.45	4.65	1.85	.0000	.0188	.0140	.0048	.36	.0000	.0000	.5386	1.8
11173	Oct. 11	V. slight.	Slight.	0.45	4.40	1.70	.0000	.0182	.0152	.0030	.38	.0000	.0000	.5184	1.8
11409	Nov. 28	V. slight.	V. slight.	0.90	5.80	3.00	.0280	.0290	.0240	.0050	.47	.0000	.0003	1.1266	1.3

Odor, distinctly vegetable and mouldy or unpleasant. —— The first two samples were collected from the river above the filter-beds and the last two from the river below the filter-beds.

CHEMICAL PRECIPITATION OF SEWAGE

AT THE

WORLD'S COLUMBIAN EXPOSITION,

CHICAGO, 1893.

BY ALLEN HAZEN,

CHEMIST, DEPARTMENT OF WATER SUPPLY, SEWERAGE AND FIRE PROTECTION.

CHEMICAL PRECIPITATION OF SEWAGE AT THE WORLD'S COLUMBIAN EXPOSITION, CHICAGO, 1893.

By ALLEN HAZEN,*

CHEMIST, DEPARTMENT OF WATER SUPPLY, SEWERAGE AND FIRE PROTECTION.

The sewage disposal works at the World's Columbian Exposition were described in the "Engineering News" of Aug. 3, 1893, which contains drawings showing many of the details of construction and arrangement.

The works were designed and built under the direction of W. S. MacHarg, C.E., engineer for water supply, sewerage and fire protection, Mr. C. M. Wilkes being first assistant engineer, and the construction of the plant and the operation of the machinery being superintended by Mr. C. E. Chester. The writer was employed to superintend the precipitation of the sewage after the construction of the works was practically completed.

The works consisted in brief of four cylindrical iron settling tanks of the Röckner-Rothe type, 32 feet high and 32 feet in diameter, with conical bottoms, which, in a height of 22 feet, tapered from 32 feet to 6 feet (see diagram on following page†). The total height was thus 54 feet, and the capacity of each tank, as ordinarily used with sewage standing 18 inches below the top, was 237,000 gallons.

The sewage from the various buildings on the Exposition grounds was forced by Shone ejectors into the iron sewers which terminated in a receiving tank 16 feet in diameter and 10 feet deep, where the sewage was screened and afterward passed through the four pipes which conveyed it to the different settling tanks, receiving and be-

* Mr. Hazen, at the time of his appointment at Chicago, was chemist in charge of the Experiment Station of the Massachusetts State Board of Health at Lawrence. He held the position at Chicago during a leave of absence granted by the Board.

† The plate from which this diagram is printed was kindly furnished by the Engineering News Publishing Company.

coming mixed with the necessary chemicals on the way. The mixed and precipitated sewage then passed down through central cylinders, 6 feet in diameter, to points near the bottoms of the tanks, where it was distributed by sheet-iron arms and the precipitate settled to the bottom, while the clarified liquid, ready for discharge into the lake, slowly rose to the top, where it was removed by a set of troughs drawing as nearly as possible equal quantities of effluent from equal

areas of surface to give a uniform and regular upward movement to the sewage in the tanks. The sludge which settled to the conical-shaped bottom was expected to slide to the point of the cone, where there was an outlet through which it could be drawn off from time to time for pressing without interrupting the continuous action of the tanks.

The filter-presses, which were exhibited by the Perrin Company, Chicago, were made by the G. H. Bushnell Company, Thompsonville, Conn., and produced at each operation fifty cakes of sludge 36 inches in diameter and about 1¾ inches thick, weighing about 47 pounds each. The central passages in the filter-presses were 4 inches in diameter, but it was found that rags and cotton waste which passed

the bars in the screen, about three-fourths of an inch apart, would frequently stop the 4-inch holes in the plates, allowing the pressure to accumulate on one side of the plate until it broke. The delay and expense of replacing plates was considerable, and it was not until the screen was covered with a finer wire screen to retain all rags and the holes in the plates were cut out to six inches in diameter that satisfactory working was obtained. The quantity of sludge which could be pressed with these presses was much below the anticipated amount, and the failure to press promptly the sludge as produced was often the limit, during a large part of the summer, of the efficiency of the plant.

The sludge cake, together with the garbage from the grounds, was burned in an Engle crematory near the sewage-disposal works.

The object of having four separate settling tanks, each of them with its independent appliances for mixing chemicals, was to allow the simultaneous application of different chemicals to sewage of precisely the same composition, and to secure in that way definite comparisons between the different chemicals when working upon a large scale. Such experiments were made almost from the first, but it soon became apparent that, within wide limits at least, the chemicals employed were not the controlling or even the leading factor in the results obtained, and that the differences between the various quantities or kinds of chemicals were often far more than offset by other conditions, which will be described beyond, over which we had less control. In this way, our investigations, instead of throwing light upon the questions which we had propounded, have been mainly confined to quite another set of problems which were scarcely anticipated before they presented themselves. We found it necessary to study, not so much how to produce a precipitate by adding chemicals to the sewage, as how to make it settle to the bottom and stay there until it could be removed and pressed.

Manner of Delivery of the Sewage at the Works.

One of the most troublesome circumstances in connection with the plant was the irregular manner in which the sewage was delivered at the works. The flow of sewage, instead of coming regularly, was subject to violent fluctuations, due to the method of collection and to the construction of the force main. The sewage was forced into

this main by twenty-six pairs of Shone ejectors located at various points on the grounds. These were operated by compressed air from a central station in Machinery Hall, and each was furnished with an automatic appliance to shut off the air as soon as the tank was sufficiently emptied. For some reason these valves often failed to act as was intended and the compressed air followed the sewage into the pipes in large quantity, pushing ahead of it the sewage in the sewer pipes with great rapidity to the precipitation works. The sewer pipes having been laid without attention to grades, contained numerous summits and depressions, and the air rapidly accumulated in the summits until finally the bulk of the sewage in the sewers had been forced to the works when at last the air commenced to come through the vertical discharge pipe. This at once relieved the pressure and the large volume of air contained in the sewers, now rapidly expanding and mixed with varying proportions of sewage, came out with explosive violence, throwing quantities of sewage into the air and even through the roof. The violence of these "blows" can be somewhat appreciated when it is stated that most of the glass in the roof twenty feet above the outlet was broken by these "blows" within a few days after the works were started, and that among other débris, a piece of lead weighing nine pounds, which had been accidentally left in the sewers, was carried up through and discharged from the vertical pipe fifty feet in height.

The number of days in each month on which such "blows" occurred, usually from one to ten and sometimes even as many as twenty "blows" occurring in a single day, was as follows: —

April (14 to 30),	13 days,	or 76 per cent. of the total number of days.
May,	23 "	" 74 " " " "
June,	13 "	" 43 " " " "
July,	15 "	" 48 " " " "
August,	19 "	" 61 " " " "
September,	22 "	" 73 " " " "
October,	26 "	" 84 " " " "

The average maximum hourly flow of sewage was about 6 per cent. of the total daily flow, and the latter never exceeded 3,200,000 gallons; it may thus be said that the normal flow of sewage which should have been obtained, if it had been delivered at the same rate as it was produced, would not have exceeded 190,000 gallons per hour, and this quantity would produce a velocity of only a foot a second

in the three-foot discharge pipe. Actually, the ordinary discharge between "blows" was much less than this, and allowed much of the suspended matter of the sewage to be deposited on the bottom of the sewer. Every time a "blow" occurred the matter which had been deposited since the previous "blow" was flushed out, and at these times sewage was obtained two or three times as concentrated as at other times. Thus for short intervals enormous quantities of highly concentrated sewage were received at the works, and the rest of the time only a reduced flow of a sewage from which the sludge had been partially removed, and frequently for a time after the "blows" occurred there was no flow at all.

Precipitants Employed.

The chemicals employed as precipitants were copperas or crude ferrous sulphate, crude alum or sulphate of alumina, a crude ferric sulphate, and lime. The copperas, alum or ferric sulphate was first added to the sewage, which then passed through a mechanical mixer containing a rapidly revolving paddle-wheel, and then received the lime. The mechanical mixers for mixing the chemicals with the sewage had no advantage over a fishway, and were more expensive and troublesome in construction and operation. The chemicals were added mainly in accordance with the principles given in the special report of the Massachusetts State Board of Health for 1890;* but owing to variation in the market prices of the various chemicals and the freight the relative costs were changed somewhat.

The analyses and costs of the various chemicals employed, together with many other data, are given in the Appendices following (pages 613–624). In calculating the costs the actual costs of chemicals delivered in Chicago are given in each case, although much lower prices were paid for some of the later lots than at the beginning.

It was found that the sludge produced with copperas and lime as precipitants was much more easily pressed than that with alum, even when used with lime; and as the cost of pressing the sludge exceeded the cost of precipitating, copperas was a more economical precipitant than alum. For the same reason more lime was used with alum than was necessary to produce the best effluent, because

* Experiments upon the Chemical Precipitation of Sewage, by Allen Hazen. Special Report of the Massachusetts State Board of Health upon Purification of Sewage and Water, 1890.

the sludge produced in presence of an excess of lime could be much more easily pressed, and the extra lime applied to the sewage was cheaper than the labor on the presses. For equal costs of treatment copperas and alum produced equally good effluents, although the effluent from copperas had more color (due to the suspended iron) than that from alum. The only ferric sulphate obtainable contained much free acid, with a disappointingly low percentage of soluble ferric oxide, and the rather poor results obtained should not be taken as disparaging the use of a better quality of reagent.

Two kinds of lime were employed, a very pure lime from Hannibal, Mo., and a local dolomite lime which was used at first, and on one or two occasions afterwards when the stock of Hannibal lime was exhausted. This lime cost only two-thirds as much and was hardly six-tenths as strong as the Hannibal lime, and to avoid unnecessarily complicating the figures in the tables given beyond, when dolomite lime was used, its weight is reckoned as its equivalent in cost of Hannibal lime, or two-thirds its actual weight.

Measurement and Composition of Sewage and Effluents.

The quantities of sewage passing each tank were determined by hourly weir measurements, so that the total daily flow of sewage was calculated from ninety-six readings. Records were kept of all these quantities, and of the weights of the chemicals employed.

Many samples of sewage and of the different effluents were analyzed to determine the efficiency of the treatments, but to avoid an unnecessarily large volume of data, only the monthly averages are given below, as it is believed that no additional information of importance would be obtained from a more detailed presentation. The method of obtaining the samples was to mix eight pint samples in a gallon bottle, the eight portions being taken at such intervals that one-eighth of the total daily flow passed between each two of them. The samples of effluent were taken in the same way, but as much later than the corresponding sewage samples as the average time required for the sewage to pass through the tanks.

The analyses are believed to represent correctly the character of effluent as discharged into Lake Michigan; but, owing to the violent fluctuations in the flow of the sewage mentioned above, the samples of sewage taken represent in general the sewage between "blows,"

when it did not contain the full amount of sludge, as, owing to the personal danger involved, satisfactory samples could not be obtained during "blows," and even if they could have been collected, it would have been impossible to determine how much sewage actually had the composition indicated by the samples. For this reason the results for loss on ignition, albuminoid ammonia and oxygen consumed in the unfiltered sewage are too low and the results of efficiency given must be taken as relative instead of absolute. The soluble constituents, including chlorine and free ammonia, were not affected in the least by sedimentation.

The averages of analyses of sewage and effluents by four weeks' periods are as follows: —

Period I. June 10 to July 7, 1893.

[Parts per 100,000.]

	Temperature. — Degrees Centigrade.	Appearance.		Residue on Evaporation.						Chlorine.	Oxygen Consumed.	Nitrogen as						Bacteria per Cubic Centimeter.
				Total Residue.			Loss on Ignition.					Albuminoid Ammonia.						
		Turbidity.	Color.	Total.	Dissolved.*	Suspended.	Total.	Dissolved.*	Suspended.			Total.	Dissolved.*	Suspended.	Free Ammonia.	Nitrites.	Nitrates.	
Sewage,	18.8	.68	1.20	58.3	38.5	19.8	28.9	11.4	17.5	6.32	3.05	.80	.29	.51	3.67	0	0	5,600,000
Average of all effluents,	18.6	.17	.64	42.7	38.1	4.6	13.1	9.8	3.3	5.00	1.37	.36	.24	.12	2.98	0	0	6,200,000
Effluent of Tank 1,	18.5	.17	.98	43.2	37.5	5.7	13.9	10.0	3.9	5.31	1.45	.38	.24	.14	3.10	0	0	5,400,000
" " " 2,	18.7	.20	.54	44.0	38.6	5.4	13.6	9.4	4.2	5.25	1.44	.39	.23	.16	3.10	0	0	7,500,000
" " " 4,	18.6	.14	.40	40.9	38.1	2.8	11.9	10.1	1.8	4.42	1.22	.32	.24	.08	2.74	0	0	5,800,000

Period II. July 8 to August 4, 1893.

	Temperature. — Degrees Centigrade.	Turbidity.	Color.	Total Residue: Total.	Total Residue: Dissolved.*	Total Residue: Suspended.	Loss on Ignition: Total.	Loss on Ignition: Dissolved.*	Loss on Ignition: Suspended.	Chlorine.	Oxygen Consumed.	Albuminoid Ammonia: Total.	Albuminoid Ammonia: Dissolved.*	Albuminoid Ammonia: Suspended.	Free Ammonia.	Nitrites.	Nitrates.	Bacteria per Cubic Centimeter.
Sewage,	21.6	.61	1.10	47.4	31.9	15.5	22.8	10.3	12.5	4.65	2.45	.62	.23	.39	2.52	0	0	3,300,000
Average of all effluents,	21.8	.15	.98	39.5	33.8	5.7	13.0	8.7	4.3	4.40	1.32	.33	.23	.10	2.60	0	0	7,700,000
Effluent of Tank 1,	21.8	.17	1.25	41.2	34.8	6.4	14.0	9.6	4.4	4.58	1.45	.37	.24	.13	2.72	0	0	7,300,000
" " " 2,	21.9	.15	.67	40.8	35.1	5.7	13.8	8.7	5.1	4.42	1.37	.34	.24	.10	2.64	0	0	6,900,000
" " " 3,	21.7	.16	1.25	38.9	32.1	6.8	13.5	8.2	5.3	4.47	1.37	.35	.24	.11	2.67	0	0	10,300 000
" " " 4,	21.8	.13	.56	37.0	33.2	3.8	10.5	8.2	2.3	4.13	1.10	.28	.20	.08	2.33	0	0	6,200,000

Period III. August 5 to September 1, 1893.

Sewage,	22.5	.67	1.10	60.0	38.5	21.5	30.7	13.3	17.4	5.55	2.81	.85	.34	.51	3.52	0	0	4,500,000
Average of all effluents,	22.1	.15	1.00	46.9	39.5	7.4	16.5	11.7	4.8	5.14	1.54	.46	.32	.14	3.55	0	0	11,500,000
Effluent of Tank 1,	22.1	.18	1.30	49.5	39.9	9.6	18.3	11.9	6.4	5.31	1.69	.50	.33	.17	3.67	0	0	9,400,000
" " " 2,	22.1	.16	.85	49.8	42.9	6.9	18.0	12.7	5.3	5.23	1.66	.48	.34	.14	3.72	0	0	15,800,000
" " " 3,	22.1	.16	1.20	48.6	40.8	7.8	17.6	12.0	5.6	5.36	1.68	.50	.35	.15	3.86	0	0	8,600,000
" " " 4,	22.0	.12	.62	39.6	34.5	5.1	12.0	10.4	1.6	4.67	1.20	.36	.27	.09	2.97	0	0	12,300,000

Period IV. September 2 to September 29, 1893.

Sewage,	21.0	.74	1.07	62.2	45.1	17.1	33.0	19.0	14.0	5.64	3.23	.86	.41	.45	4.84	0	0	2,500,000
Average of all effluents,	21.1	.18	.95	52.8	47.8	5.0	21.3	17.8	3.5	5.58	1.88	.49	.34	.15	3.95	0	0	7,000,000
Effluent of Tank 1,	21.0	.18	1.22	53.6	47.7	5.9	22.1	18.0	4.1	5.71	2.03	.54	.36	.18	3.80	0	0	3,800,000
" " " 2,	21.1	.17	.70	52.7	49.5	3.2	20.7	17.6	3.1	5.38	1.77	.46	.31	.15	4.16	0	0	9,500,000
" " " 3,	21.0	.20	1.10	55.9	48.8	7.1	23.3	18.3	5.0	5.54	2.04	.52	.34	.18	4.36	0	0	7,500,000
" " " 4,	21.1	.16	.77	49.2	45.1	4.1	19.1	17.4	1.7	5.58	1.60	.43	.35	.08	3.48	0	0	7,200,000

Period V. September 30 to October 27, 1893.

Sewage,	15.5	.75	1.12	64.0	46.9	17.1	34.6	19.7	14.9	5.81	3.64	.90	.49	.41	4.87	0	0	2,220,000
Average of all effluents,	15.5	.19	1.00	54.1	48.4	5.7	21.8	18.3	3.5	6.11	2.12	.61	.45	.16	4.11	0	0	5,900,000
Effluent of Tank 1,	15.5	.20	1.22	56.2	49.0	7.2	23.9	19.4	4.5	6.14	2.27	.64	.47	.17	3.47	0	0	3,600,000
" " " 2,	15.5	.18	.80	50.9	45.7	5.2	19.0	14.7	4.3	5.32	1.77	.53	.36	.17	4.45	0	0	10,000,000
" " " 3,	15.5	.19	1.02	55.6	49.7	5.9	22.0	18.3	3.7	6.57	2.34	.67	.47	.10	4.71	0	0	6,800,000
" " " 4,	15.5	.18	.97	53.5	49.4	4.1	22.2	20.8	1.4	6.41	2.09	.62	.51	.11	3.80	0	0	3,100,000

* Determined after filtration through filter-paper.

One of the most striking features of these analyses is the excessive number of bacteria found in the effluents,—several times as many as in the crude sewage. The causes of this remarkable condition were investigated by Drs. Wilson and Agar of the United States Army Hospital. The results obtained show that, while the sewage contained a great variety of species of bacteria, the effluents contained only a few species in large numbers, and these forms were very much more abundant than in the crude sewage. It appears that the bulk of the bacteria of the sewage was taken to the bottoms of the tanks in the precipitate, and did not exist in the effluents. The tanks, however, served as a breeding place for enormous numbers of the species found in the effluents, which were, presumably, non-pathogenic, for, so far as we know, the pathogenic forms sometimes found in water are probably incapable of growing in the conditions present in the tanks. The treatment may be said to have secured a partial but probably very incomplete removal of objectionable bacteria.

The Work of the Individual Tanks.

The quantities of sewage treated and chemicals employed for each tank during the different periods and the costs of the chemicals are shown in the following tables:—

Period I. June 10 to July 7, 1893.

	Efficiency. Per Cent. of Organic Matter Removed, as shown by Chemical Analysis.	Suspended Matter. in Effluent. Parts per 100,000.	Daily Quantity of Sewage Treated in One Tank. Thousands of Gallons.		For One Million Gallons.				
			Average.	Maximum.	Cost of Chemicals.	Lime. Pounds.*	Copperas. Pounds.	Alum. Pounds.	Ferric Sulphate. Pounds.
Tank 1, .	53†	5.7	598	806	$7 44	752	615	-	-
" 2, .	52†	5.4	598	592	8 17	412	-	623	-
" 3, .	Not in operation.								
" 4, .	60†	2.8	465	642	10 30	556	-	766	-
Period II. July 8 to August 4, 1893.									
Tank 1, .	41†	6.4	605	765	$5 79	744	376	-	-
" 2, .	45†	5.7	598	749	7 40	435	-	542	-
" 3, .	44†	6.8	604	786	8 21	731	755	-	-
" 4, .	55†	3.8	454	512	9 20	626	363	396	-

* When dolomite lime was employed only two-thirds of its weight is used in this table.

† The percentage purification indicated by these figures is too low, owing to the partial sedimentation of the sewage analyzed, already referred to on pages 602, 603. The efficiency of the plant as a whole is discussed beyond. The figures for each period, however, are comparable among themselves.

Period III. August 5 to September 1, 1893.

	Efficiency. — Per Cent. of Organic Matter Removed, as shown by Chemical Analysis.	Suspended Matter in Effluent. — Parts per 100,000.	Daily Quantity of Sewage Treated in One Tank. — Thousands of Gallons. Average.	Maximum.	For One Million Gallons. Cost of Chemicals.	Lime. — Pounds.*	Copperas. — Pounds.	Alum. — Pounds.	Ferric Sulphate. — Pounds.
Tank 1, .	41†	9.6	693	860	$6 71	1,033	385	-	-
" 2, .	43†	6.9	690	863	7 12	496	-	488	-
" 3, .	42†	7.8	693	840	8 82	1,003	671	-	-
" 4, .	58†	5.1	449	514	9 70	1,079	744	-	-

Period IV. September 2 to September 29, 1893.

Tank 1, .	38†	5.9	651	912	$7 08	1,000	391	-	-
" 2, .	46†	3.2	572	908	8 76	520	-	645	-
" 3, .	39†	7.1	665	942	8 54	854	357	-	175
" 4, .	51†	4.1	565	770	11 16	1,278	820	-	-

Period V. September 30 to October 27, 1893.

Tank 1, .	34†	7.2	674	809	$6 70	1,050	504	-	-
" 2, .	46†	5.2	522	604	9 48	677	-	723	-
" 3, .	31†	5.9	666	828	9 18	798	-	-	417
" 4, .	37†	4.1	679	882	10 82	1,800	1,002	-	-

Character of the Sludge.

The quantity of sludge pressed was estimated by weighing an occasional representative pressing. No separate record could be kept of the weights of sludge from the different tanks. Analyses of the pressed sludge were made from time to time. Its composition was quite constant, the average result being —

Moisture,	58.0 per cent.
Dry matter,	42.0 "

The dry matter contained —

Ash,	55.6 per cent.
Loss on ignition (in a radiator),	44.4 "
Fats,	8.2 "

* When dolomite lime was employed only two-thirds of its weight is used in this table.

† The percentage purification indicated by these figures is too low, owing to the partial sedimentation of the sewage analyzed, already referred to on pages 602, 603. The efficiency of the plant as a whole is discussed beyond. The figures for each period, however, are comparable among themselves.

During May and June occasional "soft" pressings were obtained, which decreased the percentage of dry matter in the total output. The presses were but rarely able to press the sludge promptly as produced, and on two occasions, July 13 and September 4 to 6, it was necessary to discharge unpressed sludge into the lake to avoid a nuisance at the works. There was also a slight accidental discharge in October. The sludge was usually pressed without the addition of lime. With copperas as a precipitant the addition of lime to the sludge had little effect upon the rapidity of pressing. With alum as a precipitant the addition of lime allowed somewhat more rapid work, but the same result was obtained by mixing the sludge from copperas with the alum sludge.

The quantities of sludge pressed in the different periods are shown in the following table. The table also includes estimates of the quantity of sludge on hand and of the quantity discharged into the lake reduced to the basis of pressed sludge cake. These estimates, based in part upon the observed heights of sludge in the tanks at different times, are necessarily only rough approximations.

Summary of Sludge Statistics.

[In tons of pressed sludge.]

Period — 1893.	Quantity of Sewage Treated. — Million Gallons.	Sludge Pressed.	Discharged into Lake Michigan.	Stock of Unpressed Sludge on hand at end of Period.	Quantity Precipitated during Period.	Per Cent. of Dry Matter in Sludge.	Tons Dry Matter in Sludge Precipitated.	Sludge per Million Gallons Sewage.
April 15 to June 9,	47	85	-	10	95	38	36.1	2.0
June 10 to July 7,	52	140	-	35	165	41	67.6	3.2
July 8 to Aug. 4,	63	192	18	10	180	42	75.6	2.9
Aug. 5 to Sept. 1,	71	250	-	45	285	42	119.7	4.0
Sept. 2 to Sept. 29,	69	297	33	10	295	40	118.0	4.3
Sept. 30 to Oct. 27,	71	320	4	30	344	38	130.7	4.8
Totals and av'ges,	373	1,284	50	80	1,364	40	547.7	3.5

Efficiency of the Process.

As stated above, it was found that large quantities of insoluble matters were removed from the sewage by sedimentation in the sewers between "blows," and when "blows" occurred these matters were washed out, so that the sewage at these times was often several times as concentrated as at other times. The concentrated sewage is not properly represented in the sewage samples taken for examina-

tion owing to the difficulty or impossibility of getting samples at these times; or, in case samples were taken, of determining what proportion of the daily flow was of the same character as the samples. For this reason the efficiency of the plant, as calculated from the chemical analyses, is considerably below the actual efficiency. We have, however, a fairly satisfactory record of the quantities of organic matters in the sludge and in the effluents, and by adding them together we can obtain an approximate estimate of the matters in the sewage, which is probably much more accurate under the circumstances than the direct calculation from the average analyses.

Efficiency of Precipitation.

[By four weeks' periods.]

PERIOD. 1893.	Average Quantity of Sewage Treated Daily. — Thousand Gallons.	Tons Organic Matter in the Sewage Calculated from Analyses.	Tons Organic Matter in the Effluent.	Tons Organic Matter in the Sludge.	Sum Total Organic Matter in the Sewage.	Corresponding Percentage of Organic Matter Removed.
April 14 to June 9, . .	880	-	-	16.2	-	-
June 10 to July 7, . .	1,866	62.9	28.5	30.4	58.9	52
July 8 to Aug. 4, . .	2,261	60.1	34.3	34.0	68.3	50
Aug. 5 to Sept. 1, . .	2,529	90.5	46.8	53.9	100.7	54
Sept. 2 to Sept. 29, . .	2,453	94.6	61.1	53.1	114.2	46
Sept. 30 to Oct. 27, . .	2,541	102.6	64.6	58.8	123.4	48
Total, June 10 to Oct. 27,	2,330	410.7	235.3	230.2	465.5	49

This calculation indicates that for the entire period the error in the average analyses of the sewage was 12 per cent., but that during the first part of the time, when "blows" were less frequent the error was less and for the last two months, with almost continual "blows," the error was greater.

The calculation shows that as a result of the operation of the works for the twenty weeks for which complete data are available, substantially one-half of the total organic matters of the sewage was removed by the precipitation. This efficiency is slightly less than was indicated for the Worcester plant by the examination of the Massachusetts State Board of Health in 1891,* and is less than we

* Annual Report, 1891, page 267. [During this examination, which was made for the week ending July 29, 1891, the average amount of organic matter removed from the Worcester sewage was 56 per cent. Since Mr. Hazen's paper was written, the annual report of the superintendent of sewers of the city of Worcester for 1893 has been issued, and extracts from it may be found on pages 343–345 of this volume. As there stated, the average amount of organic matter removed from the sewage from July 19 to Dec. 1, 1893, was about 50 per cent. ED.]

had hoped to obtain. The experiments made at Lawrence in 1889 * had indicated that chemical precipitation might remove as much as 60 per cent. of the total organic matter of the sewage.

The above calculation includes practically the whole operation of the plant, with all the conditions as they actually existed. Some of the unfavorable conditions which have been mentioned could hardly have been anticipated, and in a permanent plant would have been rectified; but there was no opportunity for changes in the short time that the plant was operated in Chicago. With the single exception of the test of the Worcester plant for one week, mentioned above, I do not know of any results which can be fairly compared with these, as it is manifestly unfair to compare the entire operation of one plant with a single set of analyses from another plant, taken, perhaps, under the most favorable conditions possible; and it must be admitted that our knowledge in regard to the total result of the operation of other chemical precipitation works is extremely limited.

The erroneous impression which may result from a single set of analyses was well illustrated by the analyses of sewage and of effluents from the Chicago works taken at noon, August 14, when the sewage had reached its full strength, but while the effluent was mainly from the diluted sewage of the preceding night. The results of these analyses indicated that 88 per cent. of the organic matters of the sewage had been removed, and were of course entirely misleading.

The disappointingly low efficiency of the plant is, I believe, to be attributed solely to the unfavorable conditions for sedimentation present in the tanks. The violent fluctuations in the flow, indeed, made it impossible to apply the chemicals to the sewage with that regularity which is necessary for the best results, and the agitation of the sewage in passing from the outlet of the sewer to the settling tanks was such that minute air-bubbles were constantly inclosed in the precipitate, often causing it to rise at first instead of sinking; but in spite of these minor difficulties I believe comparatively good results would have been obtained had better opportunities for sedimentation been present. This is strongly suggested by the record of Tank 4, which, during the first three periods, was protected from the excessive flows at the times of "blows" by sending the extra volume through

* Special Report of the Massachusetts State Board of Health on Purification of Sewage and Water, 1890.

the other tanks, and it so received a somewhat smaller and very much steadier flow. While the tank was so operated it constantly gave a very much better effluent than the other tanks, and for the whole period averaged a removal of 58 per cent. of the organic matters of the sewage passing through it at an average daily flow of 456,000 gallons, while all the other tanks for the same time removed only about 50 per cent. of the organic matters, with average flows of 635,000 gallons daily.

The prejudicial effect of these excessive flows for short periods is believed to be mainly due to the general stirring up which they gave to the contents of the tanks. They did not last long enough for any of the sewage coming in them to pass through the tanks before the ordinary rate was restored. The sloping surfaces of the bottoms of the tanks were always covered with more or less sludge, which was apparently to some extent loosened and mixed again with the sewage at these times, and did not again completely settle back, but was instead carried out by the effluent, reducing seriously the total efficiency.

It was shown by several series of chlorine determinations that the incoming sewage did not with any regularity displace the sewage previously in the tanks, but to a very large extent mixed with it, and a fraction of it appeared in the effluent almost at once, long before the displacement equalled the capacity of the tank. This tendency may have been increased by the irregularities of the flow, as it undoubtedly was by the variations in the temperature of the sewage. It was repeatedly observed that the turbidity of the effluents increased very much in the latter part of the afternoon, often being two or three times as great at five o'clock as at noon; and it was thought possible that the slightly increased temperature of the afternoon sewage might have caused it to come at once to the top and flow out, leaving the colder night and morning sewage in the tanks, or it may have been simply the effect of the continued higher flow during the hours in the middle of the day which brought this suspended matter to the top only after continuing for some hours.

The slowness with which the sludge was removed from the tanks undoubtedly contributed its share to the imperfect results, although it must be said that sludge was also present in Tank 4 when it was doing uniformly excellent work with a limited flow. The sludge which settled on the conical-shaped bottoms of the tanks did not of itself settle to the point of the cone, but required to be pushed down

at intervals of two or three days by a heavy weight which was pulled back by means of an attached rope. The fact that the lower plates overlapped the upper and were secured by a row of heavy projecting rivets, making ledges at every joint, may have had something to do with the failure of the sludge to slide. The filter presses, although their capacity was continually increased as improvements in details of construction and operation were effected, only removed the sludge so slowly that there was hardly a time during the whole operation of the plant when there was not sludge waiting to be pressed. At times the quantity so held became troublesome by decomposing, and on two occasions, as has already been stated, it was necessary to discharge some of it unpressed into the lake to avoid a nuisance at the works. There was always plenty of sludge on the bottoms and sides of the tanks to be washed out when the occasion was favorable.

Summary.

In an experimental way the sewage cleansing works of the World's Columbian Exposition have served to indicate some of the peculiarities of the form of settling-tank used, and have clearly defined some forms of construction which should not be repeated.

In a practical way they succeeded in holding back from Lake Michigan thirteen hundred tons of sludge removed from the sewage treated, and containing two hundred and fifty tons of actual organic matters. They prevented the sewage from making a nuisance along the lake front such as often resulted from one of the city's sewers discharging untreated sewage just north of the grounds, and they reduced the danger of infection of the water drawn from the Hyde Park intake and supplied to the fair grounds and to the southern part of the city of Chicago.

As an object lesson to thousands of visitors they have given new ideas as to the possibility and necessity of sewage treatment and as to modern methods of securing the cleanliness of the waters on which many cities and towns are located.

APPENDICES.

APPENDIX I.

Showing Daily Volume of Sewage in Thousands of Gallons.

Day of Month — 1893.	May.	June.	July.	August.	September.	October.
1, ...	-	776	1,942	2,421	2,810	1,979
2, ...	-	1,104	1,789	2,255	2,891	2,359
3, ...	-	1,184	1,934	2,426	2,152	2,394
4, ...	-	1,244	2,472	2,388	2,581	2,639
5, ...	-	1,353	2,309	2,703	2,662	2,424
6, ...	-	1,838	2,255	1,099	2,910	2,477
7, ...	-	1,343	2,164	2,129	3,186	2,321
8, ...	-	1,626	2,211	2,261	3,116	1,852
9, ...	-	1,452	1,918	2,434	3,147	2,935
10, ...	-	1,477	2,150	2,362	1,890	2,650
11, ...	-	1,231	2,298	2,631	2,761	2,644
12, ...	-	1,401	2,239	2,734	2,738	2,955
13, ...	-	1,904	2,364	1,419	2,858	2,714
14, ...	-	1,728	2,337	2,376	2,808	2,473
15, ...	-	1,841	2,500	2,573	2,271	1,908
16, ...	-	1,789	1,871	2,886	2,395	2,840
17, ...	-	1,943	2,407	2,550	1,879	2,722
18, ...	718	1,722	2,483	2,496	2,463	2,594
19, ...	852	1,517	2,433	2,957	2,270	2,581
20, ...	897	1,887	2,769	2,222	2,238	2,726
21, ...	865	1,602	2,523	2,764	2,380	3,040
22, ...	843	1,990	2,508	2,669	2,431	1,962
23, ...	1,062	2,033	1,420	2,746	2,360	2,729
24, ...	1,149	1,976	1,874	2,996	1,667	2,814
25, ...	1,100	1,791	2,108	2,739	2,179	2,760
26, ...	983	2,006	2,291	2,940	2,300	2,793
27, ...	1,065	2,046	2,319	1,967	2,426	2,643
28, ...	1,017	1,823	2,549	2,810	2,150	2,926
29, ...	1,049	1,828	2,651	2,811	2,093	2,207
30, ...	1,299	1,848	1,573	2,814	2,235	2,203
31, ...	1,460	-	2,022	2,825	-	1,503
Totals, ...	-	48,803	68,683	77,403	72,742	77,772
Averages, ...	-	1,627	2,216	2,497	2,425	2,509

APPENDIX II.

Showing Percentages of Total Daily Volume for the Different Hours of the Day.

Hour Ending at—	May.	June.	July.	August.	September.	October.	Whole Time.
1 A.M.,	2.9	3.1	3.0	3.1	2.7	3.0	3.0
2 "	2.2	3.3	3.1	3.2	2.7	2.5	2.9
3 "	2.6	3.2	2.9	3.0	2.8	2.1	2.8
4 "	2.3	2.7	3.0	3.0	2.7	3.1	2.9
5 "	2.5	2.3	2.9	3.0	3.1	2.9	2.9
6 "	2.9	3.6	2.9	2.9	3.3	1.8	3.0
7 "	3.7	2.6	2.8	3.0	2.7	3.2	2.8
8 "	3.6	3.2	3.0	2.9	3.0	3.5	3.2
9 "	4.8	3.8	3.7	4.0	4.0	3.5	3.8
10 "	6.3	4.6	4.8	4.6	4.4	4.7	4.6
11 "	5.5	4.8	4.7	5.0	4.6	5.4	4.9
12 M.,	4.7	4.6	5.2	5.0	5.2	5.6	5.1
1 P.M.,	6.4	5.4	5.4	5.3	5.9	5.8	5.6
2 "	5.7	5.8	5.2	5.9	6.0	5.6	5.7
3 "	6.3	5.6	5.6	5.8	5.9	5.9	5.7
4 "	5.7	6.1	5.4	5.5	5.4	7.0	5.9
5 "	6.2	5.5	5.5	5.5	5.5	6.2	5.6
6 "	4.7	5.6	5.9	5.5	5.5	5.3	5.7
7 "	4.9	5.3	4.9	5.5	5.3	5.2	5.2
8 "	3.7	5.1	4.9	4.0	5.0	4.0	4.6
9 "	3.3	4.2	4.1	3.5	4.0	3.8	4.0
10 "	3.1	3.7	3.8	3.8	3.6	3.6	3.7
11 "	3.1	3.1	3.1	3.5	2.8	3.2	3.1
12 "	2.9	2.8	4.2	3.5	3.4	2.6	3.3
Totals,	100.0	100.0	100.0	100.0	100.0	100.0	100.0

APPENDIX III.

Showing the Number of "Blows" on each Day. The actual Number of Blows is recorded, except that when they occurred at very frequent intervals for a Number of Hours in succession, the Number of Hours has been substituted for the Number of Blows.

Day of Month — 1893.	April.	May.	June.	July.	August.	September.	October.
1, ...	-	5	2	0	4	4	3
2, ...	-	7	0	0	5	3	4
3, ...	-	1	0	3	1	2	12
4, ...	-	0	0	4	4	4	2
5, ...	-	8	0	1	5	0	1
6, ...	-	5	0	0	2	0	3
7, ...	-	10	0	0	0	4	4
8, ...	-	6	0	0	2	10	0
9, ...	-	6	1	0	1	20	4
10, ...	-	10	0	0	0	10	8
11, ...	-	6	1	0	1	8	6
12, ...	-	4	10	0	7	8	2
13, ...	-	5	10	0	6	6	0
14, ...	1	1	0	2	0	7	0
15, ...	2	10	0	2	4	6	0
16, ...	1	9	0	2	10	4	4
17, ...	5	7	1	0	4	0	12
18, ...	3	5	3	2	0	2	14
19, ...	8	10	0	4	2	0	9
20, ...	5	10	4	1	0	1	11
21, ...	2	8	10	0	0	0	8
22, ...	1	1	5	2	7	8	5
23, ...	0	0	0	0	0	0	6
24, ...	0	0	1	6	0	0	15
25, ...	6	6	0	0	0	8	13
26, ...	0	5	0	2	4	8	5
27, ...	2	3	0	5	2	2	0
28, ...	9	5	4	6	3	8	7
29, ...	10	3	6	10	0	10	8
30, ...	6	0	0	1	0	0	11
31, ...	-	4	-	3	0	-	3

APPENDIX IV.

Showing Hourly Variation in Temperature of Sewage.

[Average temperature (in Centigrade degrees) of sewage at the different hours of the day for periods of ten consecutive days.]

Hour.	Sept. 15 to Sept. 24, 1893.	Oct 1 to Oct. 10, 1893.	Oct. 14 to Oct. 23, 1893.	Average 30 Days.	Above Minimum Average.
12.30 A.M.,	21.32	17.28	14.33	17.64	0.34
1.30,	21.06	17.31	14.24	17.53	0.23
2.30,	21.01	17.21	14.16	17.46	0.16
3.30,	21.10	17.06	14.09	17.42	0.12
4.30,	21.04	16.90	14.00	17.31	0.01
5.30,	21.18	16.96	13.91	17.35	0.05
6.30,	21.38	16.86	13.79	17.34	0.04
7.30,	20.89	16.93	14.08	17.30	0.00
8.30,	21.15	17.16	13.98	17.43	0.13
9.30,	21.17	17.25	14.43	17.62	0.32
10.30,	21.16	17.43	14.35	17.65	0.35
11.30,	21.33	17.60	14.75	17.89	0.59
12.30 P.M.,	21.27	17.50	14.60	17.79	0.49
1.30,	21.19	17.63	14.86	17.89	0.59
2.30,	21.22	17.70	14.73	17.88	0.58
3.30,	21.22	17.66	14.92	17.93	0.63
4.30,	21.38	17.61	14.70	17.90	0.60
5.30,	21.37	17.64	14.75	17.92	0.62
6.30,	21.44	17.56	14.40	17.80	0.50
7.30,	21.20	17.38	14.41	17.66	0.36
8.30,	21.25	17.43	14.39	17.69	0.39
9.30,	21.29	17.54	14.66	17.83	0.53
10.30,	21.21	17.83	14.52	17.69	0.39
11.30,	21.08	17.31	14.29	17.56	0.26

APPENDIX V.

Showing Hourly Range in the Chlorine of the Sewage and Effluents.

[Average chlorine in sewage or effluent at the different hours for four or five consecutive days.]

[Parts per 100,000.]

HOUR.	Sewage May 9 to 13, 1893.	Sewage May 30 to June 2, 1893.	Effluent Tank 2, May 30 to June 2, 1893.	Sewage August 21 to August 25, 1893.	Effluent Tank 1, August 21 to August 25, 1893.
12 P.M.,	4.04	8.65	5.98	3.42	7.34
3 A.M.,	1.73	5.87	6.04	1.27	6.36
6 "	1.28	3.37	6.10	0.85	5.19
8 "	0.83	-	-	2.47	4.60
9 "	0.95	0.97	5.93	4.80	4.11
10 "	0.95	1.36	5.90	5.56	3.95
11 "	1.27	2.91	5.53	6.18	4.11
12 M.,	2.24	7.75	5.85	7.13	4.18
1 P.M.,	2.63	7.28	5.23	5.29	5.01
2 "	3.70	8.60	5.32	7.74	4.46
3 "	4.85	7.69	5.39	7.16	5.17
4 "	5.51	9.24	5.47	7.24	5.68
5 "	5.55	7.89	5.57	7.96	6.57
6 "	6.26	7.87	5.66	7.45	7.14
9 "	4.90	9.36	5.97	8.42	7.89
12 "	4.04	8.65	5.98	3.42	7.76
Average daily flow of sewage estimated at	750,000	1,160,000		2,794,000	

It is seen that with the low flow in May the day sewage was being slowly forced out of the sewers all through the night. During the forenoon nothing but slightly dirty water was received, and at about noon the morning sewage first made its appearance at the works. In August, with three times as great a flow, the morning sewage was noticeable as early as eight o'clock, and at nine it had become quite concentrated. Afterward it slowly increased in strength until nine in the evening, after which the sewage was rapidly displaced by clear water, and from midnight until morning very little sewage matter was received.

APPENDIX VI.

Samples of Sewage and Effluent taken at Noon when the Sewage had reached its full Concentration and while the Effluent was derived from the Dilute Sewage of the Preceding Night.

[Parts per 100,000.]

	Temperature. — Degrees Centigrade.	Appearance.		Residue on Evaporation.						Chlorine.	Oxygen Consumed.	Nitrogen as					
				Total Residue.			Loss on Ignition.					Albuminoid Ammonia.					
		Turbidity.	Color.	Total.	Dissolved.*	Suspended.	Total.	Dissolved.*	Suspended.			Total.	Dissolved.*	Suspended.	Free Ammonia.	Nitrites.	Nitrates.
Sewage,	22.5	.70	1.20	84.2	55.0	29.2	50.0	26.6	23.4	6.42	3.52	1.00	.39	.61	4.60	0	0
Effluent,	21.5	.06	0.20	22.4	21.4	1.0	7.6	6.8	0.8	2.03	0.85	0.14	.14	.00	1.10	0	0

* Determined after filtration through filter-paper.

APPENDIX VII.

Showing Monthly Attendance at the Fair in comparison with the Volume of Sewage produced.*

Month—1893.	Sewage. — Thousands of Gallons.	Approximate Attendance in Thousands.				Sewage per Admission. — Gallons.	Sewage per Admission and 30 Per Cent. for Midway Plaisance.
		Paid Admissions.	Photographic Passes.	Workmen.	Total Attendance.		
May, . .	29,709†	1,050	466	465	1,981	15.0	19.5
June, . .	48,808	2,675	900	300	3,875	12.5	16.3
July, . .	68,683	2,762	1,216	100	4,078	16.9	22.0
August, . .	77,408	3,515	1,172	-	4,687	16.5	21.4
September, .	72,742	4,659	1,150	-	5,809	12.5	16.3
October, .	77,772	6,866	1,168	-	8,034	9.7	12.6
Totals and Averages,	375,112	21,527	6,072	865	28,464	13.2	17.2

* The sewage received at the cleansing works was from Jackson Park only, the Midway Plaisance draining into city sewers, and, as the attendance included both Jackson Park and the Plaisance, it is necessary for this calculation to estimate the quantity of sewage produced in the Plaisance.

† Estimated.

APPENDIX VIII.

Showing the Quantities of Various Substances and the Number of Bacteria in the Sewage for Each Person admitted to the Fair Grounds.

MONTH — 1893.	Sewage per Person. — Gallons.	Sewage per Person. — Liters.	Chlorine per Person. — Grams.	Nitrogen in Free Ammonia per Person. — Grams.	Nitrogen in Albuminoid Ammonia per Person. — Grams.	Total Nitrogen per Person. — Grams.	Bacteria in Billions per Person.
June, . .	16.3	62	3.68	2.05	.51	3.07	260
July, . .	22.0	84	4.20	2.42	.53	3.48	284
August, . .	21.4	81	4.40	2.71	.63	3.97	356
September, .	16.3	62	3.49	3.00	.58	4.06	155
October, . .	12.6	48	2.78	2.33	.43	3.19	106
Averages, .	17.7	67	3.71	2.50	.53	3.56	232

APPENDIX IX.

*Showing Quantity, Composition and Cost of Chemicals used in Precipitation.**

I. SULPHATE OF ALUMINA.

[From ROBERT STEVENSON & Co., Chicago.]

Cost, in barrels, ... $47 00 a ton.

Analysis.

Insoluble in water, ...	.06 per cent.
Alumina, ...	15.64 "
Ferric oxide, ...	.50 "
Sulphuric acid, ...	34.88 "
Moisture and undetermined, ...	48.92 "

II. SULPHATE OF ALUMINA.

[From MERRIMAC CHEMICAL COMPANY, Boston.]

Cost, in bulk, ... $20 40 a ton.

Analysis.

Insoluble in water, ...	6.11 per cent.
Alumina, ...	13.17 "
Ferric oxide, ...	1.31 "
Sulphuric acid, ...	32.66 "
Moisture and undetermined, ...	46.75 "

Taking into account the difference in analyses the first sample was twice as expensive as the second.

* The cost includes freight to Jackson Park in each case.

III. Copperas.

[From Washburn & Moen, Waukegan, Ill.]

Cost, in bulk, ... $13 40 a ton.

Analysis.

Insoluble in water,	0.24 per cent.
Ferrous oxide,	25.21 "
Sulphuric acid,	28.50 "
Moisture and undetermined,	46.05 "

IV. Crude Ferric Sulphate.

[From Jobbins & Van Ruymbecke, Aurora, Ill.]

Cost, in barrels, ... $32 00 a ton.

Analysis.

Insoluble in water,	12.00 per cent.
Ferric oxide,	22.76 "
Sulphuric acid,	45.00 "
Moisture and undetermined,	20.24 "

V. Lime.

[From Chicago Union Lime Company]

Cost, in barrels, $0.60 a barrel of 200 pounds, . . . $6 00 a ton.

Analysis.

Insoluble in acid,	0.10 per cent.
Alumina and ferric oxide,	1.00 "
Calcium oxide,	57.10 "
Magnesium oxide,	38.60 "
Water, carbonic acid and undetermined,	3.20 "
Lime soluble in water,	55.01 "

VI. Lime.

[From Hannibal Lime Co., Hannibal, Mo.]

Cost, in barrels, $0.75 a barrel of about 170 pounds, . $8 80 a ton.
Cost, in bulk, $0.22 a bushel, ... 6 50 "

Analysis.

Alumina and ferric oxide,	1.50 per cent.
Calcium oxide,	95.00 "
Water, carbonic acid and undetermined,	3.50 "
Lime soluble in water,	93.00 "

Even at the higher price paid for the Hannibal lime it was a much more economical lime to use on account of the much higher percentage of available lime. The magnesia present in the local lime is without value in sewage treatment; it simply adds itself to the sludge.

During the first weeks an attempt was made to apply chemicals in proportion to the flow of sewage without having any fixed schedule, but the plan proved to be too complicated, with the four sets of chemicals for the four tanks, each of which required separate regulation, particularly during those hours when it was impracticable for either myself or my assistant to closely supervise the operation, and after a little while the following arrangement was made and worked very satisfactorily: a schedule was prepared showing the quantity of alum, copperas, or ferric sulphate to be dissolved for each tank at 7.30 A.M., 3.30 and 11.30 P.M. The men on each shift commenced work half an hour earlier than these times. Each man weighed the quantities of chemicals shown by the schedule into the respective tanks used for this purpose and dissolved them in a tank full of water, using at first steam, and in the summer after the water became warmer, compressed air to thoroughly stir up the contents of the tanks. The solutions so prepared were allowed to flow into the sewage, varying the rates with changes in the flow of sewage as well as possible, but in such a way as to make the solution last through and yet be exhausted at the expiration of the eight hours' shift. The lime schedule was arranged somewhat differently. The lime was always slaked in barrel lots, and the schedule showed the hours at which lime was to be added. Each lot was made to last until the next lot was slaked, varying the flow with the flow of sewage as far as possible within that time.

A constant stream of water was kept running through the lime box in use to stir up and wash out the lime as required. Water from a tap instead of sewage was used both for this purpose and for dissolving the other chemicals, on account of the practical difficulty of regulating a small stream of sewage with the slight head available. Putting the chemicals into the sewage at four points instead of one, so reduced the quantity and the flow of water required to carry the chemicals at each point, that when sewage was used for mixing the chemicals the gates were continually becoming stopped with sewage matters. The quantity of water used for dissolving the alum, copperas and ferric sulphate was about six thousand gallons daily; the quantity used for carrying the lime may be roughly estimated at from twenty to forty thousand gallons.

The schedules of chemicals were arranged to make the quantities employed on the different shifts approximately proportional to the quantities of sewage, some allowance being made, however, for the

more dilute sewage during the night. Usually the same quantities of chemicals were used through one week, except that as a rule only half as large a quantity was required on Sunday, while on special days the quantities were increased. With copperas, as much lime was ordinarily used as would give a strong reaction with phenolphthalein in the effluent. With ferric sulphate and alum the quantity of lime used was less and was added more to give a sludge which could be easily pressed than with reference to the effluent, as sewage is sufficiently alkaline to decompose these salts without the use of lime.

Variations in the quantities of sewage necessitated very frequent changes in the chemical schedules, and the proportions of the total quantities used on the different shifts were also varied to meet changing conditions. In calculating the cost of chemicals the weights in the note books have been taken, and these weights in all cases foot up somewhat differently from the weights bought, the error usually being under 3 per cent., sometimes in one direction, sometimes in the other. During the first part of the time when Alum, I. and Lime, V. were being used, the costs were very much higher than for corresponding quantities of Alum, II. and Lime, VI. During two weeks, one ending July 14 and the other September 8, the amount of lime used was limited by the stock on hand.

Quantities in Pounds of Various Chemicals Employed (by Weeks).

Week ending — 1893.	Sewage. — Thousands of Gals.	Alum, I.	Alum, II.	Copperas, III.	Ferric Sulphate, IV.	Lime, V.	Lime, VI.	Total Cost.	Cost per Million Gallons.
April 21, . .	2,000*	2,000	-	-	-	-	-	$47 00	-
April 28, . .	3,000*	2,728	-	-	-	770	-	66 52	-
May 5, . .	5,000*	4,531	-	-	-	-	-	106 47	-
May 12, . .	6,000*	5,131	-	-	-	-	-	120 57	-
May 19, . .	6,800*	5,630	-	390	-	1,081	-	134 91	-
May 26, . .	6,919	4,950	-	1,650	-	4,808	-	141 80	$20 49
June 2, . .	7,770	1,860	3,140	1,750	-	7,891	-	111 13	14 30
June 9, . .	9,540	2,658	2,400	2,030	-	6,729	-	120 72	12 65
June 16, . .	11,371	-	4,900	2,450	-	8,015	-	90 44	7 95
June 23, . .	12,694	-	5,460	2,880	-	2,357	5,430	106 06	8 35
June 30, . .	13,318	-	5,180	4,120	-	-	8,776	118 18	8 87
July 7, . .	14,865	-	5,020	5,080	-	-	9,983	127 99	8 61
July 14, . .	15,517	-	4,795	4,815	-	-	2,785	93 16	6 00
July 21, . .	16,986	-	4,900	5,040	-	-	11,110	130 25	7 66
July 28, . .	15,069	-	2,170	6,870	-	-	11,963	121 16	8 04
Aug. 4, . .	15,736	-	2,250	7,020	-	-	14,258	132 98	8 45
Aug. 11, . .	15,619	-	2,170	6,885	-	-	13,538	128 26	8 21
Aug. 18, . .	17,034	-	2,210	7,020	-	-	15,365	137 07	8 05
Aug. 25, . .	19,093	-	2,440	7,380	-	-	16,841	148 59	7 78
Sept. 1, . .	18,977	-	2,610	7,620	-	-	17,068	148 18	7 81
Sept. 8, . .	19,498	-	2,535	7,410	-	8,279	-	98 34	5 04
Sept. 15, . .	17,968	-	2,600	7,935	-	969	18,208	165 08	9 18
Sept. 22, . .	16,056	-	2,600	4,874	1,624	-	18,637	167 66	10 44
Sept. 29, . .	15,175	-	2,610	6,525	1,630	-	17,742	172 92	11 39
Oct. 6, . .	16,507	-	2,400	6,825	1,625	-	17,463	150 10	9 09
Oct. 13, . .	18,071	-	2,865	7,800	2,185	-	18,393	173 09	9 58
Oct. 20, . .	17,849	-	2,600	6,825	1,950	-	16,701	157 35	8 81
Oct. 27, . .	18,741	-	2,710	7,110	2,030	-	16,680	161 66	8 62

* Estimated.

APPENDIX X.

Distribution of Mineral Matters.

The following table contains calculations of the quantities of mineral matters in the sewage, chemicals employed, sludge and effluent for the different periods. Without discussing in detail the method of calculation, it may be stated that it is estimated that each hundred pounds of lime employed adds one hundred and seventy pounds to the mineral matters of either the sludge or of the effluents, and that one hundred pounds of the other chemicals add fifty-three pounds in the same way.

	June 10 to July 7.	July 8 to Aug. 4.	Aug. 5 to Sept. 1.	Sept. 2 to Sept. 29.	Sept. 30 to Oct. 27.	Total.
Tons of lime used,	15.5	20.0	31.4	30.4	34.6	132.0
Tons of other chemicals,	17.5	18.9	19.2	18.5	23.5	97.6
Lime x1.70,	26.4	34.1	53.4	51.6	58.9	224.4
Other chemicals x0.53,	9.3	10.0	10.1	9.9	12.4	51.7
Sum,	35.7	44.1	63.5	61.5	71.3	276.1
Mineral matter in sewage (tons),	64.0	64.9	86.3	83.7	87.5	386.4
Sum,	99.7	109.0	149.8	155.2	158.8	662.5
Mineral matter in sludge,	37.2	41.6	65.8	64.9	71.9	281.4
Mineral matter in effluent,	64.4	69.9	89.6	90.3	95.8	410.0
Sum,	101.6	111.5	145.4	155.2	167.7	691.4
Excess of matters in effluent and sludge,	1.9	2.5	5.6	10.0	8.9	28.9

The excess of mineral matters in the sludge and effluent is to be attributed to the same causes as the excess of organic matters, but the discrepancy is less, owing to the small quantity of insoluble mineral matters in the sewage.

APPENDIX XI.

Cost of Construction and of Operation of Sewage Cleansing Works.

The cost of construction of the sewage cleansing works was about $55,000, of which more than $20,000 was for the building. The approximate costs of operation for different periods are shown in the following table, in which the expenses are distributed as well as possible between the treatment of the sewage and the pressing of the sludge. The figures do not include the cost of superintendence, the cost of the chemical laboratory, or the cost of burning the sludge, which was done at an Engle crematory.

	April 14 to June 9.	June 10 to July 7.	July 8 to Aug. 4.	Aug. 5 to Sept. 1.	Sept 2 to Sept. 29.	Sept. 30 to Oct. 27.	Total April 14 to Oct. 27.
Cost of chemicals, . . .	$840	$442	$477	$562	$604	$642	$3,567
Labor applying chemicals, .	215	261	217	217	217	230	1,357
Total cost of precipitation,	$1,055	$703	$694	$779	$821	$872	$4,924
Cost of fuel oil, . . .	659	412	423	373	414	331	2,612
Labor on engine and presses,	1,590	1,021	1,018	1,022	962	1,058	6,671
Total cost of pressing, .	$2,249	$1,433	$1,441	$1,395	$1,376	$1,389	$9,283
Total cost of operation, .	3,304	2,136	2,135	2,174	2,197	2,261	14,207
Million gallons sewage treated,	47	52	63	71	69	71	373
Tons sludge cake pressed, .	85	140	192	250	297	320	1,284

MORTALITY REPORTS.

SUMMARY OF THE WEEKLY MORTALITY REPORTS FROM CITIES AND TOWNS.

This summary comprises the returns of deaths made at the end of each week by the town clerks, city registrars and other officials having in charge the vital statistics of cities and towns.

These returns are compiled each week and published as a bulletin, one copy of which is sent to each city and town in the State.

These reports are necessarily incomplete since they are voluntary, and comprise the mortality statistics of a part of the population only, the reporting places being chiefly the cities and large towns.

The estimated population of the cities and towns contributing to the returns of 1893 was about 1,460,000, or about 60 per cent. of the total population of the State.

The data embraced in this summary are the following: —

Average height of barometer for each week.
Mean or daily maximum temperature.
Mean or daily minimum temperature.
Rainfall expressed in inches.
Total deaths reported for each week.
Deaths of children under five years.
Deaths from infectious diseases.
Deaths from consumption.
Deaths from acute lung diseases.
Deaths from typhoid fever.
Deaths from diarrhœal diseases.
Deaths from scarlet-fever.
Deaths from measles.
Deaths from diphtheria and croup.
Deaths from puerperal fever.
Deaths from whooping-cough.
Deaths from malarial fever.
Deaths from small-pox.
Deaths from erysipelas.

Summary.

Date.	Barometer.	Maximum Thermometer. Mean for each Week.	Minimum Thermometer. Mean for each Week.	Rain. Inches.*	Humidity. Mean for each Week.	Total Deaths.	Deaths under Five.	Consumption.	Acute Lung Diseases.	Typhoid Fever.	Diarrhœal Diseases.	Scarlet-fever.	Measles.	Diphtheria and Croup.	Puerperal Fever.	Whooping-cough.	Malarial Fever.	Small-pox.	Erysipelas.
Jan. 7,	29.66	31	18	-	68	594	180	79	110	16	6	13	2	25	1	-	-	-	1
14,	29.65	21	4	-	69	573	174	65	115	6	7	21	1	32	6	-	1	-	3
21,	30.08	21	7	-	73	591	162	74	124	10	6	20	2	22	1	3	-	-	4
28,	30.20	34	20	2.54	73	546	165	63	117	5	5	12	1	32	1	-	-	-	7
Feb. 4,	30.28	34	20	-	72	524	165	53	122	9	6	10	-	23	1	-	-	-	-
11,	30.31	38	17	-	70	597	193	42	140	8	3	14	2	15	-	2	-	-	2
18,	30.09	37	26	-	71	630	231	78	183	7	6	10	1	27	4	1	-	-	5
25,	29.46	33	14	4.05	59	614	195	64	112	10	8	13	2	21	1	1	-	-	1
March 4,	29.93	35	23	-	68	560	198	77	107	6	3	10	1	22	-	2	-	-	3
11,	29.95	38	27	-	72	624	196	66	130	6	4	16	3	19	2	6	-	1	4
18,	29.94	42	26	-	68	638	211	62	132	6	5	21	-	20	1	4	-	-	1
25,	30.19	43	29	3.33	78	653	201	79	126	3	8	12	3	25	-	3	-	-	1
April 1,	30.11	43	31	-	63	609	163	64	140	2	13	12	1	16	-	-	-	-	4
8,	30.11	48	32	-	65	637	165	88	148	7	5	10	1	13	-	3	2	-	3
15,	30.08	52	39	-	66	671	199	97	166	5	9	11	3	19	-	3	-	-	2
22,	30.00	48	37	-	72	625	180	63	170	12	8	12	4	17	-	3	1	-	5
29,	30.09	56	40	3.19	69	580	177	61	146	5	6	13	1	16	2	1	-	-	7
May 6,	29.92	58	43	-	85	638	190	72	144	3	7	9	6	20	1	2	-	-	2
13,	30.09	67	49	-	62	638	179	62	139	5	8	7	9	16	-	2	-	-	7
20,	29.68	62	47	-	84	569	177	62	118	6	6	14	6	13	2	1	-	-	2
27,	27.87	74	55	5.32	61	535	168	56	91	8	4	15	6	18	1	1	-	-	1
June 3,	30.01	66	51	-	76	479	147	57	72	7	-	8	8	14	1	1	-	-	3
10,	30.03	80	61	-	71	545	175	59	70	7	15	10	5	13	3	4	-	-	1
17,	30.05	70	59	-	89	465	145	57	64	-	11	8	5	14	-	2	-	-	1
24,	29.89	72	54	2.72	84	427	123	39	62	5	23	8	-	6	1	2	-	-	4
July 1,	30.04	67	54	-	88	442	180	68	49	5	23	8	-	12	-	1	-	-	2
8,	29.92	80	62	-	70	444	143	55	42	-	31	7	1	13	1	2	-	-	1
15,	28.82	69	62	-	61	518	227	51	39	4	94	5	2	11	-	4	-	-	1
22,	29.90	86	66	-	64	649	310	51	31	6	176	9	-	12	3	1	-	-	-
29,	29.99	76	61	2.27	69	788	404	51	38	5	234	8	3	16	-	3	1	-	-
Aug. 5,	29.99	78	68	-	68	775	368	58	37	4	245	5	1	10	1	2	-	-	-
12,	29.95	81	63	-	76	715	385	66	24	5	242	6	1	10	-	3	1	-	-
19,	29.94	71	58	-	68	718	444	60	33	15	213	4	-	14	1	2	1	-	-
26,	29.99	77	63	5.22	81	626	310	60	24	11	167	8	3	7	1	3	1	-	-

Sept. 2,	29.99	71	62	-	74	644	339	61	28	13	169	8	1	14	1	1	2	-	-
9,	29.99	71	53	-	69	587	298	65	30	10	124	8	-	16	-	4	-	-	-
16,	30.14	72	54	-	77	607	294	59	34	12	120	4	1	12	1	6	-	-	1
23,	29.89	65	63	-	57	587	257	64	37	17	86	7	-	15	1	-	1	-	-
30,	30.11	60	40	2.38	75	561	247	64	28	15	116	5	1	20	2	2	-	-	2
Oct. 7,	29.99	63	51	-	82	548	194	57	40	16	56	10	1	22	-	3	-	-	-
14,	29.99	70	61	-	67	538	184	40	31	16	42	10	2	22	1	3	-	-	1
21,	30.31	60	45	-	67	535	170	56	48	19	30	5	1	25	-	3	-	-	-
28,	30.09	62	49	4.01	59	623	164	47	48	16	33	6	3	27	-	3	-	-	3
Nov. 4,	30.52	54	39	-	65	480	162	78	50	14	28	6	1	29	1	1	-	-	1
11,	30.31	49	35	-	71	509	177	60	52	7	16	11	1	26	1	5	-	-	-
18,	29.98	51	36	-	67	437	135	57	72	13	16	9	1	21	-	4	-	-	2
25,	29.94	44	35	2.17	69	540	150	60	70	11	11	9	4	27	1	2	-	-	-
Dec. 2,	30.09	45	31	-	69	499	138	61	71	17	7	14	-	30	-	2	-	-	-
9,	30.19	37	22	-	82	623	150	56	86	9	9	13	1	27	1	2	-	-	-
16,	29.90	21	15	-	69	566	168	63	116	8	6	34	1	30	-	3	-	1	3
23,	30.19	41	24	-	70	648	160	63	153	11	6	14	3	28	1	-	1	2	3
30,	29.95	43	30	2.94	70	655	180	63	169	4	9	19	1	18	1	6	-	1	1
Totals,	-	-	-	40.14	-	30,247	10,759	3,217	4,484	427	2,497	527	100	1,013	49	178	10	4	94
Weekly averages,	-	-	-	-	-	632	207	62		8	48	10	2	20					1.8
Ratio per 1,000 deaths,	-	-	-	-	-	-	355.7	106.3		1.12	82.5	17.4	3.3	33.49					3.11
Ratio per 1,000 population,	-	-	-	-	-	20.73	7.37	2.20		.29	1.71	.36	.06	.69					.064

Average reporting population, . . . 1,458,540

* The figures in this column are the monthly averages for New England, being the mean of about 155 stations.

Total Deaths.

The whole number of deaths reported for the year 1893 from the cities and towns contributing to these reports was 30,247, and the average number per week was 582. The greatest number of deaths reported in a single week was 788 in the week ending July 29, and the least number was 427 in the week ending June 24.

The weekly average number of deaths reported for each month was as follows: —

January,	576	July,	568
February,	591	August,	708
March,	621	September,	574
April,	622	October,	534
May,	595	November,	496
June,	479	December,	563

The months in which the greatest mortality was reported were March, April and August, and those in which there was the least reported mortality were June, October and November. The percentages of mortality in each of the four quarters of the year were as follows: —

	All Ages.		Ages Under Five Years.	
	Numbers.	Percentages.	Numbers.	Percentages.
First quarter,	7,158	23.65	2,276	21.15
Second quarter,	7,418	24.52	2,188	20.34
Third quarter,	8,641	28.57	4,126	38.35
Fourth quarter,	7,035	23.26	2,169	20.16
	30,247	100.00	10,759	100.00

The death rate of reporting cities and towns was 20.74 per 1,000, the estimated population being 1,458,840.

Deaths under Five Years.

The reported number of deaths of children under five years of age was 10,759, and the average weekly number was 207.

The greatest number reported in one week was 444 in the week ending August 19, and the least number was 123 in the week ending June 24. The ratio of the deaths of this class to the total reported mortality was 35.5 per cent., which was slightly greater than that of the preceding year (34.1 per cent.).

The average weekly number of deaths of children under five years of age by months was as follows: —

January,	170	July,	243
February,	196	August,	377
March,	203	September,	281
April,	177	October,	183
May,	178	November,	158
June,	148	December,	161

The months having the greatest number of deaths of this class were July, August and September, and those having the least number were June, November and December.

Consumption.

The number of reported deaths from consumption was 3,217 and the weekly average was 62. The greatest number of deaths reported from this cause in a single week was 97 in the week ending April 15, and the least number was 39 in the week ending June 24.

The average weekly number of reported deaths from this cause in each month was as follows: —

January,	70	July,	55
February,	59	August,	61
March,	71	September,	61
April,	75	October,	52
May,	63	November,	64
June,	53	December,	56

The months having the greatest number of deaths from this cause were March and April, and those having the least number were June and October.

The following table presents the variations from the weekly average number of deaths from this cause for the past four years: —

	1890.	1891.	1892.	1893.		1890.	1891.	1892.	1893.
January,	+42	+4	+13	+8	July,	−8	−4	−3	−7
February,	+3	−4	−8	−3	August,	−4	−3	−4	−1
March,	+3	−5	−1	+9	September,	−5	−3	−11	−1
April,	+1	+4	+7	+13	October,	−11	+3	−5	−10
May,	+1	+6	0	+1	November,	−12	−4	−4	+2
June,	−3	−2	−5	−9	December,	0	+5	−1	−6

The ratio of reported deaths from consumption to the mortality reported from all causes was 106.35 per 1,000, while that of previous years was as follows: —

1886,	156.5	1890,	130.0
1887,	141.1	1891,	116.5
1888,	134.2	1892,	111.3
1889,	125.0	1893,	106.5

The ratio to the reporting population in 1893 was 2.20 per 1,000, as compared with 2.35 in 1892.

Acute Lung Diseases.

The number of reported deaths from acute lung diseases (bronchitis, pneumonia, pleurisy and asthma) during the year was 4,484, and the weekly average was 86. The greatest number of deaths reported from this group of causes in a single week was 170, in the week ending April 22, and the least number 20, in the week ending September 9.

The average weekly number of reported deaths from these causes for each month was as follows: —

January,	116	July,	54
February,	127	August,	29
March,	124	September,	31
April,	154	October,	40
May,	123	November,	64
June,	67	December,	119

The months having the greatest number of reported deaths from these causes were February and April, and those having the least number were August and September.

The ratio of reported deaths from acute lung diseases to the reported mortality from all causes was 14.82 per 1,000.

The estimated death rate per 1,000 of the reporting population from these causes was 3.07, as compared with 2.82 for the previous year.

Typhoid Fever.

The total number of reported deaths from this cause in 1893 was 427, and the average weekly number was 8. The greatest number reported in any single week from this cause was 19 in the week ending October 21, and the least number was 2 in the week ending April 1.

The average weekly number of deaths reported from this cause for each month was as follows: —

January,	9	July,	4
February,	8	August,	9
March,	5	September,	13
April,	6	October,	17
May,	5	November,	11
June,	5	December,	10

The months having the least number of deaths from this cause were March, June and July, and those having the greatest number were September, October and December.

The ratio of reported deaths from typhoid fever to the reported mortality from all causes was 14.12 per 1,000, and the ratio to the reporting population was .29, as compared with .31 in the previous year.

Diphtheria and Croup.

The total number of reported deaths from diphtheria and croup in 1893 was 1,013, and the average number in each week was 20. The greatest number reported in a single week from these combined causes was 37, in the week ending October 28, and the least number was 6, in the week ending June 24.

The average weekly number of reported deaths from these causes for each month was as follows: —

January,	28	July,	16
February,	22	August,	10
March,	21	September,	15
April,	16	October,	29
May,	27	November,	26
June,	12	December,	27

The months having the greatest number of reported deaths from these causes were January, October and December, and those having the least number were June, August and September. The ratio of deaths from diphtheria and croup to the reported mortality from all causes was 33.49 per 1,000, and the death rate of the reporting population was .69 per 1,000, that of the previous year being .66.

Scarlet-fever.

The reported deaths from scarlet-fever in 1893 were 527, and the average weekly number was 10. The greatest number of reported deaths from this cause in a single week was 21, in the week ending March 18, and the least number reported in a single week was 3, in the week ending September 9. The average weekly number reported in each month was as follows: —

January,	16	July,	7
February,	12	August,	4
March,	15	September,	5
April,	12	October,	5
May,	11	November,	9
June,	8	December,	13

The months having the greatest number of deaths from this cause were January and March, and those having the least number were August and October.

The ratio of deaths from this cause to the reported deaths from all causes was 17.44 per 1,000, and the death rate of the reporting population from this cause was .36 per 1,000, that of the previous year being .32.

Measles.

The total number of reported deaths from measles in 1893 was 100, and the weekly average number was 2.

The greatest number in a single week was 9. There were nine weeks in which no deaths from measles were reported.

The average weekly number reported in each month was as follows: —

January,	1	July,	1
February,	1	August,	1
March,	2	September,	1
April,	2	October,	1
May,	7	November,	2
June,	3	December,	1

The ratio of deaths to the reported mortality from all causes was 3.31 per 1,000, and the death rate from this cause was .06 per 1,000 of the reported living population, as compared with .03 in 1892.

DIARRHŒAL DISEASES.

The diseases included in this group are diarrhœa, dysentery, cholera morbus and cholera infantum.

From these causes combined the number of deaths reported in 1893 was 2,497, and the weekly average number was 48. The greatest number reported in a single week was 245 in the week ending August 5, and there were none reported in the week ending June 3.

The average weekly number of reported deaths from these causes in each month was as follows: —

January,	6	July,	112
February,	6	August,	217
March,	5	September,	124
April,	8	October,	41
May,	6	November,	13
June,	12	December,	7

The months having the greatest number of reported deaths from these causes in 1893 were July, August and September, and those having the least were January, February and March.

The deaths from these causes in the third quarter of the year constituted 82 per cent. of the number of deaths from the same causes for the entire year. The ratio of reported deaths to the reported mortality for all causes was 82.5 per 1,000, and the death rate of the reporting population from these causes was 1.71 per 1,000, as compared with 1.66 in 1892.

WHOOPING-COUGH, MALARIAL FEVER, ERYSIPELAS, PUERPERAL FEVER AND SMALL-POX.

The essential statistics relating to these five diseases are embraced in the following table: —

	Total Deaths Reported.	Weekly Average.	Ratio per 1,000 of Reported Deaths from All Causes.	Ratio per 1,000 of Estimated Population.
Whooping-cough,	119	2.0	3.93	.06
Erysipelas,	94	1.8	3.11	.06
Puerperal fever,	48	.9	1.58	.03
Malarial fever,	12	.2	.40	.008
Small-pox,	5	.1	.16	.003

REPORTS OF INFECTIOUS DISEASES.

REPORTS OF INFECTIOUS DISEASES.

For very many years laws have existed in this State requiring that notices of cases of diseases dangerous to the public health should be given to the board of health of the city or town in which they have occurred; but the vital importance of such a system of notification does not appear to have become impressed firmly upon the public mind until a comparatively recent period. It was not until 1889, in fact, that a law was enacted in England requiring such notices, and even then it was made a matter of local option except in London.

The chief advantages of a system of notification lie in the possibility which is thus given to a local board of health to determine the extent of prevalence of an epidemic or a localized outbreak, and to inquire into the local causes which have operated to produce it. The board can then act intelligently in applying the proper remedies for preventing its further spread.

In Massachusetts there can be no doubt that the law relative to notification has been productive of excellent results in the prevention of disease, especially in the cities and large towns. It has furnished the local boards of health with the necessary information relative to the origin of outbreaks of infectious disease, and in many instances enabled them to take timely steps for preventing further outbreaks. The recent law requiring local boards to keep records upon this important matter, has furnished information as to the prevalence of certain diseases in the principal cities and towns of the State. In the smaller towns it is probable that instances of failure to comply with the provisions of the statute are much more frequent than they are in cities.

Up to 1883 no definite authority was given by statute for notification to the central authority, the State Board of Health. In that year a law was enacted requiring immediate notice to be given by local boards to the State Board of Health of the occurrence of cases of small-pox.

Ten years later by the provisions of chapter 302 of the Acts of 1893, it was required that reports of all diseases dangerous to the public health should be made to the State Board of Health.

The following is the act of 1893 relative to reporting dangerous diseases to the State Board of Health: —

[CHAPTER 302 OF THE ACTS OF 1893.]

(1.) When the board of health of any city or town has had notice of the occurrence of a case of small-pox or any other disease dangerous to the public health in such city or town, such board of health shall, within twenty-four hours after the receipt of such notice, notify the state board of health of the same.

(2.) If the board of health of the city or town, in which a case of small-pox or any other disease dangerous to the public health has occurred, refuses or neglects to send a notice as required in section one, such city or town shall forfeit its claim upon the Commonwealth for the payment of any expenses which may be incurred as provided in section eighty-three of chapter eighty of the Public Statutes.

Since no definite statement was made in this act defining the term "dangerous to the public health" the Board deemed it proper, in order to relieve local authorities of uncertainty in the matter, to specify the diseases which, in the opinion of the Board, should be thus reported under the provisions of the act.

For this purpose a circular was prepared in which it was specified that, in addition to *small-pox*, the following diseases shall be considered as dangerous to the public health within the meaning of the foregoing act: *scarlet-fever*, *measles*, *typhoid fever*, *diphtheria*, *membranous croup*, *cholera*, *yellow fever*, *typhus fever*, *cerebro-spinal meningitis*, *hydrophobia*, *malignant pustule*, *leprosy and trichinosis*.

This circular was issued in September, 1893. Previous to that date very few returns had been received in compliance with the terms of the act.

The act was approved May 3, 1893, and the first returns to be received came from the city of Cambridge, which has sent continuous returns since May, 1893. A few more cities and towns complied with the provisions of the act during the months of June, July and August, but no large number of cities and towns made returns until a circular was prepared notifying them of the enactment of the law. This circular was issued to each city and town in

September, after which the returns came with regularity from many cities and towns.

The following is the form of the return recommended by the Board and issued by it in the form of postal cards to each local Board of Health: —

Report of Infectious Diseases to the State Board of Health, as required by the provisions of Chapter 302, Acts of 1893.

____________________189

Cases of disease, dangerous to the public health, reported within the past twenty-four hours to the Board of Health of the TOWN / CITY of ________________

	Number of Cases of each disease.
Small-pox,	
Scarlet-fever,	
Diphtheria,	
Membranous Croup,	
Measles,	
Typhoid Fever,	

(Signed) ____________________
Secretary or Agent of Board of Health.

This postal card report should in all cases be signed by the Secretary or Clerk of the local Board of Health, or by the authorized Agent of the Board.

In the blank spaces should be written the names of any of the unusual forms of infectious diseases enumerated below, if such should occur: —

Cholera, Typhus Fever, Yellow Fever, Cerebro-spinal Meningitis, Hydrophobia, Malignant Pustule, Glanders and Trichinosis.

The results of these notices are published each week in the Weekly Bulletin of Mortality and Infectious Diseases.

The following tables embrace the results of these returns for the fractional part of the year 1893 which elapsed after the enactment of the law: —

Cases of Diseases dangerous to the Public Health reported by Local Boards of Health to the State Board of Health for the Fractional Year ending Dec. 31, 1893.

Total number of reported cases of diphtheria and croup,	1,109
Total number of reported cases of scarlet-fever,	2,914
Total number of reported cases of typhoid fever,	1,525
Total number of reported cases of measles,	1,503
Total number of reported cases of small-pox,	35
	7,086
Additional cases of small-pox reported under the statute of 1883,	8
Total,	7,094

The following table shows the distribution of these cases by months of the year.

Reports were not generally forwarded to the State Board until after the public notice was given in September, which accounts for the small number before that date.

Reports of Dangerous Diseases Classified by Months.

1893.	Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.
May,	4	33	4	43	-
June,	4	41	2	226	1
July,	10	23	5	3	-
August,	14	28	23	5	-
September,	191	453	541	79	2
October,	316	670	493	201	2
November,	305	870	283	389	8
December,	265	796	174	557	22
Totals,	1,109	2,914	1,525	1,503	35

The following table presents the names of the reporting cities and towns with the number of cases of each disease reported by the local boards of health: —

Cases of Infectious Diseases reported to the State Board of Health from One Hundred and Seventy-five Cities and Towns during 1893.

	Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.
Acushnet, . .	-	-	1	-	-
Agawam, . .	-	1	-	-	-
Amesbury, . .	7	82	18	-	-
Amherst, . .	-	-	1	-	-
Arlington, . .	15	-	2	-	-
Ashburnham, .	-	1	-	-	-
Ashland, . .	-	1	-	-	-
Athol, . . .	-	4	8	-	-
Attleborough, .	7	-	5	1	-
Auburn, . .	-	-	1	-	-
Ayer, . . .	-	80	3	-	-
Bedford, . .	2	-	-	-	-
Belmont, . .	1	2	1	-	-
Berlin, . .	-	1	-	-	-
Beverly, . .	1	5	8	-	-
Bolton, . .	-	2	-	-	-
BOSTON, . .	520	816	445	161	27
Bourne, . .	1	-	-	-	-
Bradford, . .	5	1	2	-	-
Brewster, . .	-	-	-	1	-
Bridgewater, .	-	-	1	-	-
Brimfield, . .	-	-	1	-	-
BROCKTON, . .	5	28	16	-	-
Brookfield, . .	-	1	-	-	-
Brookline, . .	1	7	5	2	1
CAMBRIDGE, .	52	467	70	70	-
Carlisle, . .	-	5	-	-	-
Chelmsford, .	-	-	2	-	-
CHELSEA, . .	10	27	12	-	-
Cheshire, . .	11	-	-	1	-
Chesterfield, .	-	-	1	16	-
CHICOPEE, . .	1	-	7	1	-
Concord, . .	8	8	8	-	-
Conway, . .	-	-	1	-	-
Cottage City, .	-	5	1	-	-

	Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.
Dalton, . .	-	1	-	-	-
Danvers, . .	-	2	2	-	-
Dedham, . .	1	28	6	-	-
Dighton, . .	1	4	2	-	-
Douglas, . .	2	-	-	-	-
Dover, . . .	2	-	-	-	-
Dracut, . .	-	2	-	-	-
Easthampton, .	1	1	-	-	-
Edgartown, .	-	4	-	-	-
Egremont, . .	-	1	-	-	-
Erving, . .	1	5	2	-	-
Essex, . . .	1	-	-	-	-
EVERETT, . .	-	84	8	5	-
FALL RIVER, .	12	52	87	8	-
FITCHBURG, .	1	7	10	8	-
Foxborough, .	-	8	-	-	-
Franklin, . .	-	2	11	-	-
Gardner, . .	-	1	17	-	-
GLOUCESTER, .	5	6	6	-	-
Grafton, . .	-	-	1	2	-
Greenfield, . .	8	-	1	-	-
Groton, . .	-	2	1	-	-
Halifax, . .	-	1	-	-	-
Hampden, . .	8	-	-	-	-
Hanson, . .	1	5	-	-	-
Hardwick, . .	5	17	-	-	-
Hatfield, . .	-	1	-	-	-
HAVERHILL, .	5	19	31	1	-
Hingham, . .	-	2	-	-	-
Hinsdale, . .	-	-	1	9	-
Hull, . . .	1	1	1	-	-
Huntington, .	-	6	6	-	-
Ipswich, . .	8	18	8	2	-
Kingston, . .	-	-	8	-	-
Lancaster, . .	-	-	2	-	-

Cases of Infectious Diseases, etc. — Continued.

	Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.		Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.
LAWRENCE, .	16	52	24	4	-	Norwood, . .	1	23	-	-	-
Leicester, . .	2	-	2	1	-	Oakham, . .	-	-	-	8	-
Leominster, .	4	4	5	1	-	Orange, . .	-	1	7	2	-
Lexington, . .	-	-	1	-	-	Oxford, . .	-	-	3	-	-
Lincoln, . .	-	2	-	-	-	Palmer, . .	-	2	-	-	-
Littleton, . .	-	4	-	-	-	Paxton, . .	-	-	1	-	-
LOWELL, . .	22	66	37	6	1	Peabody, . .	2	3	2	-	-
Ludlow, . .	-	1	-	-	-	Pembroke, . .	-	-	1	-	-
Lunenburg, .	-	-	-	1	-	Pepperell, . .	-	2	3	-	1
LYNN, . . .	25	130	58	3	-	PITTSFIELD, .	2	44	17	65	-
MALDEN, . .	5	48	17	91	-	Plymouth, . .	27	3	8	27	-
Mansfield, . .	1	15	1	-	-	QUINCY, . .	2	22	23	2	-
Marblehead, .	11	56	6	-	-	Randolph, . .	-	1	-	-	-
MARLBOROUGH, .	6	2	3	142	-	Raynham, . .	-	-	2	-	-
Maynard, . .	2	6	-	-	-	Reading, . .	1	8	1	-	-
MEDFORD, . .	5	6	6	1	-	Rochester, . .	-	1	1	-	-
Melrose, . .	-	23	3	20	-	Rockland, . .	1	5	-	-	-
Medway, . .	-	1	-	-	-	Rockport, . .	1	2	-	-	-
Methuen, . .	1	-	1	-	1	Rowley, . .	-	-	6	-	-
Middlefield, .	-	1	-	-	-	SALEM, . .	7	45	37	-	-
Middleton, . .	-	-	1	-	-	Salisbury, . .	-	2	-	-	-
Milford, . .	-	1	9	1	-	Sandisfield, . .	-	-	2	-	-
Millbury, . .	6	5	8	96	-	Saugus, . .	-	1	2	8	-
Monson, . .	-	8	3	5	-	Scituate, . .	1	-	-	-	-
Montague, . .	-	7	-	-	-	Seekonk, . .	-	2	-	-	-
Natick, . .	2	17	3	8	-	Sharon, . .	-	2	2	-	-
NEW BEDFORD, .	7	76	169	118	2	Shutesbury, .	-	-	1	-	-
NEWBURYPORT, .	26	1	5	-	-	Somerset, . .	-	-	-	24	-
NEWTON, . .	34	43	15	3	-	SOMERVILLE, .	28	193	34	2	1
North Adams, .	3	27	11	2	1	SPRINGFIELD, .	4	82	27	12	2
NORTHAMPTON, .	6	24	47	22	-	Stoneham, . .	5	4	-	-	-
North Andover, .	1	-	-	3	-	Stow, . . .	-	-	-	7	-
No. Attleboro', .	4	4	3	-	-	Sturbridge, . .	-	1	-	-	-
No. Brookfield, .	-	6	-	-	-	Swampscott, .	2	7	-	-	-
Northfield, . .	-	-	1	-	-	TAUNTON, . .	2	22	4	-	-

Cases of Infectious Diseases, etc. — Concluded.

	Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.		Diphtheria and Croup.	Scarlet-fever.	Typhoid Fever.	Measles.	Small-pox.
Tewksbury,	-	1	-	-	-	Westford,	1	7	1	-	-
Topsfield,	-	-	1	-	-	Westhampton,	2	-	-	-	-
Townsend,	-	-	1	-	-	Westminster,	-	1	2	-	-
Upton,	1	-	-	2	-	West Newbury,	5	-	-	-	-
Uxbridge,	-	-	2	3	-	W. Stockbridge,	-	4	-	-	-
Wakefield,	12	2	1	5	-	Weston,	-	2	-	-	-
Wales,	-	2	-	-	-	West Springfield,	-	3	1	-	-
WALTHAM,	13	5	7	-	-	Weymouth,	2	-	-	-	-
Ware,	5	2	-	-	-	Whitman,	5	1	-	-	-
Wareham,	2	-	1	-	-	Williamstown,	1	-	7	-	-
Warren,	1	4	2	-	-	Winchendon,	6	-	2	-	-
Warwick,	-	-	-	3	-	Winthrop,	-	1	-	-	-
Watertown,	2	3	3	27	-	Winchester,	3	15	6	-	-
Wayland,	1	-	-	-	-	Windsor,	-	-	-	1	-
Wenham,	-	2	-	-	-	WOBURN,	18	14	6	-	-
Webster,	1	1	8	-	-	WORCESTER,	55	55	95	500	-
West Boylston,	3	-	-	-	-	Other cases of small-pox,*	-	-	-	-	8
W. Bridgewater,	-	9	-	-	-	Totals,	1,109	2,914	1,525	1,503	43
Westborough,	-	2	-	-	-						

Total (including small-pox), ... 7,094

* These were cases of small-pox reported under the statute of 1883 by cities and towns which made no reports of other diseases under the law of 1893.

The foregoing table shows that exactly one-half of the local boards of health in the State have complied with the law, and have sent returns to the State Board of Health of the cases of disease "dangerous to the public health" reported to them, leaving one-half of the towns from which no reports whatever have been received.

These 175 cities and towns reporting, however, constitute much more than one-half the population, since in this list are embraced all of the cities except Holyoke.

The following classified list contains the names of those towns whose boards of health failed to comply with the terms of the statute of 1893, no reports having been forwarded by them to the State Board of Health of the occurrence of cases of infectious or dangerous diseases. The list of towns is classified according to population.

I. Cities.

Holyoke.

II. Towns having Populations of More than 5,000 in Each.

Adams,
Andover,
Blackstone,
Clinton,
Framingham,
Hyde Park,
Middleborough,
Revere,
Spencer,
Southbridge. — 10.

III. Towns having a Population of Over 1,000 but Less than 5,000 in Each.

Abington,
Acton,
Ashfield,
Avon,
Barnstable,
Barre,
Belchertown,
Bellingham,
Billerica,
Braintree,
Buckland,
Canton,
Charlton,
Chatham,
Chester,
Cohasset,
Colrain,
Dartmouth,
Deerfield,
Dennis,
Dudley,
Duxbury,
East Bridgewater.
Easton,
Fairhaven,
Falmouth,
Freetown,
Georgetown,
Granville,
Great Barrington,
Groveland,
Hadley,
Hanover,
Harvard,
Harwich,
Holbrook,
Holden,
Holliston,
Hopedale,
Hopkinton,
Hubbardston,
Hudson,
Lanesborough,
Lee,
Lenox,
Longmeadow,
Manchester,
Marshfield,
Mattapoisett,
Medfield,
Merrimac,
Milton,
Nantucket,
Needham,
Newbury,
New Marlborough,
Northborough,
Northbridge,
Norton,
Norwell,
Orleans,
Petersham,
Provincetown,
Rehoboth,
Royalston,
Sandwich,
Sheffield,
Shelburne,
Sherborn,
Shirley,
Shrewsbury,
Southampton,
South Hadley,
Southborough,
Sterling,
Stockbridge,
Stoughton,
Sudbury,
Sutton,
Swansea,
Templeton,
Tisbury,
Walpole,
Wellesley,
Wellfleet,
West Brookfield,
Westport,
Wilbraham,
Williamsburg,
Wilmington,
Wrentham. — 91.

IV. Towns having Less than 1,000 Inhabitants in Each.

Alford,
Ashby,
Becket,
Berkley,
Berlin,
Bernardston,
Blandford,
Boxborough,
Boxford,
Boylston,
Burlington,
Carver,
Charlemont,
Chilmark,
Clarksburg,
Cummington,
Dana,
Dunstable,
Eastham,
Enfield,
Florida,
Gay Head,
Gill,
Granby,
Greenwich,
Goshen,
Gosnold,
Hamilton,
Hancock,
Hawley,
Heath,
Holland,
Lakeville,
Leverett,
Leyden,
Lynnfield,
Marion,
Mashpee,
Mendon,
Millis,
Monterey,
Montgomery.
Monroe,
Mount Washington,
Nahant,
New Ashford,
New Braintree,
New Salem,
Norfolk,
North Reading,
Otis,
Pelham,
Peru,
Phillipston,
Plainfield,
Plympton,
Prescott,
Princeton,
Richmond,
Rowe,
Russell,
Rutland,
Savoy,
Southwick,
Sunderland,
Tolland,
Truro,
Tyngsborough,
Tyringham,
Washington,
Wendell,
Whateley,
Worthington. — 73.

A review of this classified list leads to some conclusions as to the causes of the failure of so large a number to comply with the provisions of the statutes.

In the first place, the ratio of the population of the cities and towns failing to report in each of the foregoing classes as compared with the total population of the towns of each class shows that the cities and large towns have complied with the provisions of the act much more generally than the small towns.

In Class I., the cities, Holyoke is the only city failing to comply, and its population, by census of 1890, constitutes but 2.5 per cent. of the population represented in Class I.

In Class II. the population of the ten towns failing to report was 25.7 per cent. of the total population of the towns of that class.

In Class III. the population of the ninety-one towns failing to report was 48 per cent. of the total population of the towns of that class.

In Class IV. the population of the seventy-three towns failing to report was 75 per cent. of the total population of the towns of that class.

This great difference between the action of the authorities of cities and of small towns in this matter suggests two definite reasons for the considerable degree of non-compliance with the terms of the statute.

1. The non-existence of separate local boards of health in small towns having an organization for sanitary purposes only. An inquiry of the State Board made a few years since showed that boards of health independent of the selectmen existed in only one-half of the towns in the State. This being the case, the selectmen acting as boards of health are largely interested in matters of an economic or administrative character not closely related to the public health, and as a consequence matters pertaining to the health of towns are much neglected, and among them, undoubtedly, the reporting of cases of infectious diseases.

Many attempts to remedy this defect by legislative action have been made in past years, but with little success.

2. As a matter of fact infectious diseases do not prevail in sparsely settled populations to so great an extent as among the densely settled suburban districts, so that there were undoubtedly some of the very small towns in which none of the specified diseases occurred during the year. This fact is brought out very clearly in the twenty-third report of the Board (1891), wherein is shown the relation of the mortality from eight different diseases, most of them of the infectious class, to the density of the population.

While the mortality does not necessarily represent the prevalence of disease it bears a very close relation to it. In that report it was shown that for a period of twenty years (1871–90) there were two towns in the State in which there had been no deaths from diphtheria and croup, fifteen towns in which there had been no deaths from scarlet-fever, one town in which there had been no deaths from typhoid fever, 183 towns in which there had been no deaths from small-pox and ninety-five towns in which there had been no deaths from measles.

FOOD AND DRUG INSPECTION.

FOOD AND DRUG INSPECTION.

The following report comprises the work of the Board for the year ending Sept. 30, 1893, in the inspection of food and drugs.

The force employed in this department of work was the same as that of the previous year, and consisted of the following: —

Dr. CHARLES P. WORCESTER,	*Analyst.*
Prof. CHARLES A. GOESSMANN,	*Analyst.*
Mr. ALBERT E. LEACH,	*Assistant Analyst.*
JOHN H. TERRY,	*Inspector.*
JOHN F. MCCAFFREY,	*Inspector.*
HORACE F. DAVIS,	*Inspector.*

The work of the Board in this department has been conducted during the year in the laboratory at 994 Washington Street, Boston, temporarily occupied for this purpose until the new laboratory in the State House Extension is completed.

The whole number of samples of food and drugs examined during the year was 6,409, making the whole number examined 53,573 for the entire period since the enactment of the general food and drug acts in 1882. This number (6,409) was greater than that of any previous year.

The following summary embraces the work done during the year: —

Number of samples of milk examined,	3,073
Number of samples above standard,	1,545
Number of samples below standard,	1,528
Percentage of adulteration or deficiency,	49.7
Number of samples of other kinds of food (not milk),	3,009
Number of samples above standard,	2,637
Number of samples below standard,	372
Percentage of adulteration,	12.3
Number of samples of drugs examined,	327
Number of samples of good quality,	228
Number of samples adulterated, as defined by the statutes,	99
Percentage of adulteration,	30.3
Total examinations of food and drugs,	6,409
Total examinations of good quality,	4,410
Total examinations not conforming to the statutes,	1,999
Percentage of adulteration,	31.2

STATISTICAL SUMMARY.

FOOD AND DRUG INSPECTION (1883-1893).

SUMMARY.	YEARS.					
	1883.	1884.	1885.	1886.	1887.	1888.
Number of samples of milk examined,	218	1,123	2,219	2,085	3,081	2,825
Number of samples above standard,	35	347	1,297	1,323	1,900	1,705
Number of samples below standard,	183	776	922	762	1,181	1,120
Percentage of adulteration,	83.9	69.1	41.7	36.5	38.3	39.6
Number of samples of other kinds of food (not milk),	477	839	1,552	1,353	1,789	2,079
Number of samples of good quality,	328	432	883	863	1,263	1,680
Number of samples adulterated, as defined by the statutes,	149	407	669	490	526	399
Percentage of adulteration,	31.2	48.5	43.1	36.2	29.4	19.2
Number of samples of drugs examined,	603	682	1,007	888	550	862
Number of samples of good quality,	357	431	571	463	400	634
Number of samples adulterated, as defined by the statutes,	246	251	436	425	150	228
Percentage of adulteration,	40.8	36.8	43.3	47.8	27.3	26.4
Total examinations of food and drugs,	1,298	2,644	4,778	4,326	5,420	5,766
Total examinations of good quality,	720	1,210	2,751	2,649	3,563	4,019
Total examinations not conforming to the statutes,	578	1,434	2,027	1,677	1,857	1,747
Percentage of adulteration,	44.5	54.2	42.7	38.7	34.3	30.3
Expense of collection, examination and prosecution,	$2,931 56	$5,529 60	$8,557 43	$8,025 34	$8,803 62	$8,915 41
Expense of collection, examination and prosecution, per sample,	2 26	2 09	1 79	1 85	1 62	1 54

FOOD AND DRUG INSPECTION (1883-1893) — *Concluded.*

SUMMARY.	YEARS.					TOTALS.
	1889.	1890.	1891.	1892.	1893.	
Number of samples of milk examined,	3,219	3,236	2,726	3,271	3,073	27,076
Number of samples above standard,	1,971	1,858	1,629	1,757	1,545	15,367
Number of samples below standard,	1,248	1,378	1,097	1,514	1,528	11,709
Percentage of adulteration,	38.7	42.6	40.2	46.3	49.7	43.2
Number of samples of other kinds of food examined (not milk),	1,635	2,349	2,144	2,441	3,009	19,667
Number of samples of good quality,	1,242	1,913	1,577	2,042	2,637	14,860
Number of samples adulterated, as defined by the statutes,	393	436	567	399	372	4,807
Percentage of adulteration,	24.0	18.6	26.4	16.3	12.3	24.4
Number of samples of drugs examined,	600	400	424	487	327	6,830
Number of samples of good quality,	503	325	352	312	228	4,576
Number of samples adulterated, as defined by the statutes,	97	75	72	175	99	2,254
Percentage of adulteration,	16.2	18.7	17.0	35.9	30.3	22.0
Total examinations of food and drugs,	5,454	5,985	5,294	6,199	6,409	53,573
Total examinations of good quality,	3,716	4,096	3,558	4,111	4,410	34,803
Total examinations not conforming to the statutes,	1,738	1,889	1,736	2,088	1,999	18,770
Percentage of adulteration,	31.9	31.5	32.8	33.7	31.2	35.0
Expense of collection, examination and prosecution,	$10,356 28	$10,013 04	$10,019 41	$11,180 30	$10,454 11	$94,786 10
Expense of collection, examination and prosecution, per sample,	1 89	1 67	1 89	1 80	1 63	1 77

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Percentage of adulteration,	16.2	18.7	17.0	35.9	30.3	22.0
Total examinations of food and drugs,	5,454	5,985	5,294	6,199	6,409	53,573
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Expense of collection, examination and prosecution,	$10,356 28	$10,013 04	$10,019 41	$11,180 30	$10,454 11	$94,786 10
Expense of collection, examination and prosecution, per sample,	1 89	1 67	1 89	1 80	1 63	1 77

It would be manifestly impossible from the statistics presented in the foregoing table to form a definite conclusion either in relation to the extent of adulteration of food which exists in Massachusetts or of its relative prevalence when the same statistics are compared with those of other countries conducting a similar line of work.

The reasons for the very marked contrast between the results reported by the British analysts and those of Massachusetts are stated in the last Report of the Board (24th report, p. 608), and one of these reasons appears to be shown more clearly in the present report wherein the general table of statisties has been rearranged in such a manner as to present the ratio of adulteration of "other samples of food," not including milk.

To what extent the legal standard of milk in Massachusetts affects the ratio of adulteration, as published in the foregoing table, may be shown by the following statement.

Out of 2,235 samples of milk taken by the inspectors of the Board in the years 1886–1889, the total solids of which were known, and all of which contained less than 13 per cent. of solids, 1,504 or 67.3 per cent. contained from 12 to 13 per cent. of solids. Nearly all of these and many more would, under the standards of most countries which have adopted a standard, have been deemed to be milk of good standard quality, since the standard in most countries is 11.50 of total solids. But in Massachusetts all of this number, except those which were collected in the months of May and June, must be reckoned as adulterated milk. The effect of this statutory provision upon the published ratio of adulteration consequently gives to our published statistics an unfavorable showing, which at the first glance might be easily misconstrued. The statistics presented in Dr. Worcester's report for the present year still further confirm this statement.

As a matter of fact, however, actual or intentional adulteration of this most important article of food is much less common than it was found to be at the beginning of the period of active enforcement of the laws relating to food and drug inspection.

The continuous work of the Board and the marked improvement in local inspection in cities have effected a marked change, which nothing but vigilant and continuous supervision could have accomplished.

What is Adulterated Milk?

The high percentages of samples of milk which are shown by the continuous reports of the Board to be below the legal standard of 13 per cent. of solids make it necessary to make an occasional statement of the cause.

The term "adulterated milk," under the statutes of Massachusetts, may signify milk which is simply below the legal standard of 13 per cent. of solids and nothing more, or, in other words, a natural milk, just as produced by the cow, having no other disqualification except its deficiency in total solids. The "percentage of adulteration" reported by the Board in its monthly bulletins is largely made up of this class of samples.

The second form of "adulterated milk" consists of milk which has been subjected to certain alterations by human interference. These are chiefly the addition of water, the removal of cream, the addition of coloring matter and of substances employed to preserve the milk from souring.

This second class is very much smaller in number than the former class. It is not practicable to separate the two classes and to draw an exact line between them, but it is certain that the ratio of the class of samples intentionally adulterated is very much less than it was before active measures were taken for the suppression of such conditions.

In 1884 the Board made a large number of examinations of natural milk, the samples in all cases being collected by inspectors who witnessed the milking. From the results of these analyses it would be safe to say that out of 100 samples taken at random from 100 animals throughout the different dairies in the State under varying conditions of breed, of age, time of year and methods of feeding, about thirty would prove to be below the legal standard of 13 per cent. of solids.

Among this 30 per cent. of animals the ratio of Holstein cows would probably be greater than the ratio of such cows among the 70 per cent. whose milk is found to be above the legal standard.

Very careful attention has been given to this subject in other countries, where the subject of milk inspection is deemed of very high importance, both in its sanitary and in its economic relations.

In a recent article in the *Zeitschrift für Fleisch und Milch Hygiene*, Dr. Martiny states that the percentage of the various constituents of milk to be used as a standard must be determined by the average percentage found in a given district, since this may vary somewhat. Milk in North Germany is not quite so rich in solids as that of South Germany, and in the former it shows an average of 3.3 per cent. of fat in 12 per cent. of dried solids, with a specific gravity of 1031.5, while in the latter the average solids are 12.4 per cent. and the fat 3.5.

The same writer states his belief that the percentage of fats may be increased to more than 4 per cent. in a total of 13 or 14 per cent. of solids by appropriate feeding.

The methods of feeding employed in many of the dairies which furnish the milk supply of our large cities are those which are intended to secure an increased quantity of milk at the expense of its quality, and the selection of breeds of cows whose milk is notoriously poor in quality acts in the same direction of impoverishing the quality of the milk.

In commenting upon the difficulty of subjecting to inspection the entire milk supply of a city at frequent intervals, Martiny concludes that —

1. The sale of milk should only be allowed by officially designated dealers, and in order to facilitate frequent inspection he suggests the limitation of the number of vendors of milk as is done in England and in Italy.

2. Dealers should give evidence of an intelligent knowledge of the requirements necessary for the sale of pure milk both from a sanitary and from an economic point of view.

3. Milk inspection should not be confined to market milk but should extend to the dairies.

4. In every city a well-equipped laboratory should be maintained for the scientific examination of milk.

It is gratifying to know that since the enactment of the general statute of 1882 (chap. 263), and the work which has followed during the ten years or more which have elapsed, very much more attention has been given to milk inspection by local authorities. Several of the principal cities of the State employ the services of trained inspectors who devote either the whole or a considerable portion of their time to the careful analysis of milk by laboratory

methods, and the number of such cities which find it to be for their interest to employ a trained inspector is gradually increasing.

The report of the analyst also shows that the artificial coloring of milk, once quite a common practice in the large cities, is now very rarely found, the vigorous warfare against this objectionable form of adulteration having practically suppressed it.

Among the examinations of milk reported by the analyst special attention is called to the report upon condensed milk, an article which is now largely used and has a wide field of usefulness as a convenient form of food for special purposes.

Food, other than Milk.

In the examination of other kinds of food during the year special attention has been given to the examination of the most important and widely used of all foods — bread; and also of cheese, another valuable article of nutriment.

The points of interest noted in regard to bread are the weight of loaves, the percentage of water and of solids, the per cent. of ash in terms of solids, the acidity and the price charged for each loaf.

The average weight of loaves was found to be 404 grammes, or 13½ ounces.

The per cent. of moisture was quite uniform, in most instances being about 42 or 43 per cent. of the weight of the loaf, leaving 57 or 58 per cent. of solids.

The price was quite uniformly five cents per loaf, rarely four cents, for loaves of ordinary size and weight.

No adulterations are mentioned by the analyst, and at the low price of flour in the United States the adulteration of flour or of bread is of extremely rare occurrence.

The examination of samples of cheese showed a fairly uniform quality and price, the latter being at sixteen cents per pound.

Omitting four samples of special sorts, the average total solids were found to be 66.3 per cent., the fat 35 per cent., the solids, not fat, 31.3 per cent., and the water 33.6 per cent.

The following tables present the usual statistics relative to the notices sent by the Board to parties (usually retailers) from whom samples of adulterated food or drugs have been obtained during the year: —

Cities and Towns to which Notices were sent on Account of Adulterated Articles of Food other than Milk.

Adams,	4	New Bedford,	1
Boston,	43	North Adams,	5
Cambridge,	17	North Brookfield,	1
Everett,	1	Orange,	1
Fall River,	17	Pittsfield,	5
Gilbertville,	2	Taunton,	1
Gloucester,	6	Ware,	1
Holyoke,	4	Webster,	1
Hopedale,	1		
Lowell,	1	Total,	113
Medford,	1		

Cities and Towns to which Notices were sent on Account of Adulterated Milk.

Boston,	10	Newton,	6
Brockton,	1	Norwood,	2
Brookline,	1	Orange,	1
Cambridge,	37	Pittsfield,	1
Canton,	1	Plymouth,	2
Chelsea,	10	Provincetown,	3
Dedham,	7	Quincy,	3
Everett,	10	Revere,	7
Fall River,	6	Salem,	12
Fitchburg,	4	Salisbury Beach,	1
Gloucester,	15	Somerville,	31
Grafton,	1	South Framingham,	1
Hyde Park,	6	Springfield,	3
Lawrence,	3	Stoneham,	1
Littleton,	2	Taunton,	1
Lynn,	22	Walpole,	1
Malden,	21	Waltham,	2
Marblehead,	2	Watertown,	3
Medfield,	3	Woburn,	15
Medford,	5	Worcester,	5
Milford,	2		
Nantasket Beach,	2	Total,	274
New Bedford,	2		

Cities and Towns to which Notices were sent on Account of Adulterated Drugs.

Adams,	1	North Adams,	1
Amherst,	2	Palmer,	1
Boston,	17	Provincetown,	1
Brookline,	1	Springfield,	1
Gloucester,	3	Taunton,	5
Millis,	1		
New Bedford,	2	Total,	36

Prosecutions.

In the last report a condensed summary of the prosecutions conducted by the Board for the entire period since the enactment of the food and drug statutes was presented. The same table is herewith published, together with the results of the prosecutions of the year ending Sept. 30, 1893: —

Number of Complaints Entered in Court.

Year.	Food not including Milk.	Drugs.	Milk.	Total.	Convictions.	Fines Imposed.
1883,	-	5	4	9	8	-‡
1884,	2	1	45	48	44	-‡
1885,*	50	1	68	119	103	-‡
1886,†	10	-	10	20	19	-‡
1887,	30	-	34	64	60	-‡
1888,	22	-	43	65	61	$2,042 00
1889,	74	-	66	140	124	3,889 00
1890,	78	-	24	102	96	3,919 00
1891,	96	5	49	150	135	2,668 00
1892,	52	12	72	136	123	3,661 70
1893,	26	3	67	96	92	2,476 00
Totals,	440	27	482	949	865	18,655 70

* To May 1, 1886. † Four months only. ‡ No record kept.

Ratio of convictions to complaints, 91.1 per cent.

Note. — All complaints entered before May 1, 1886, were under the direction of the Board of Health, Lunacy and Charity, and all after that date were under the direction of the State Board of Health.

Under the provisions of chapter 289 of the Acts of 1884, which require the Board to report annually to the Legislature the "number of prosecutions made under" the food and drug acts, "and an itemized account of all money expended in carrying out the provisions thereof," the following report was transmitted to the General Court in January, 1894: —

OFFICE OF THE STATE BOARD OF HEALTH,
13 BEACON STREET, BOSTON, January, 1894.

To the Honorable Senate and House of Representatives of the Commonwealth of Massachusetts, in General Court assembled.

The following summary is made in compliance with the provisions of chapter 289, section 2, of the Acts of 1884, requiring the State Board of Health to "report annually to the Legislature the number of prosecutions made under chapter 263 of the Acts of 1882, and an itemized account of all money expended in carrying out the provisions thereof."

The whole number of prosecutions made by authority of the Board against offenders, under the provisions of the food and drug acts, for the year ending Sept. 30, 1893, was 96.

The cities and towns in which the articles were sold, and in respect to which complaints were entered in court, the character of the articles found to be adulterated, or fraudulently sold, the dates of the trials and their result, are presented in the following table: —

MILK AND MILK PRODUCTS.

Complaints Entered for Fraudulent Sales of Milk.

PLACE.	DATE.	RESULT.
In Boston,	Aug. 1, 1893,	Convicted.
Cambridge,	June 9, 1893,	"
Cambridge,	June 17, 1893,	"
Chelsea,	March 24, 1893,	"
Fall River,	April 27, 1893,	"
Fall River,	May 4, 1893,	"
Fall River,	May 4, 1893,	"
Fall River,	May 4, 1893,	"
Fall River,	May 4, 1893,	"
Fall River,	June 20, 1893,	"
Salem,	April 29, 1893,	"
Salem,	April 29, 1893,	"
Salem,	April 29, 1893,	"

For Fraudulent Sales of Milk — Continued.

Place.	Date.	Result.
In Salem, ...	April 29, 1893, . .	Convicted.
Salem, ...	June 26, 1893, . .	"
Salem, ...	Aug. 28, 1893, . .	"
Salem, ...	Aug. 28, 1893, . .	"
Salem, ...	Aug. 28, 1893, . .	"
Taunton, . . .	July 29, 1893, . .	"
Taunton, . . .	July 29, 1893, . .	"
Gloucester, . . .	Jan. 3, 1893, . .	"
Gloucester, . . .	Aug. 2, 1893, . .	"
Gloucester, . . .	Aug. 31, 1893, . .	"
Quincy, ...	Aug. 24, 1893, . .	"
Quincy, ...	Aug. 24, 1893, . .	"
Chicopee, . . .	June 9, 1893, . .	"
Woburn, . . .	Nov. 16, 1892, . .	"
Spencer, ...	Oct. 18, 1892, . .	"
Hardwick, . . .	Oct. 5, 1892, . .	"
Lee, ...	Oct. 25, 1892, . .	"
Carlisle, ...	Nov. 25, 1892, . .	"
North Adams, . . .	Nov. 10, 1892, . .	"
Greenfield, . . .	Nov. 11, 1892, . .	"
Oakham, ...	Jan. 28, 1893, . .	"
Canton, ...	Jan. 11, 1893, . .	"
Dedham, ...	Feb. 23, 1893, . .	"
Sutton, ...	March 24, 1893, . .	"
Berlin, ...	May 20, 1893, . .	"
Topsfield, . . .	May 20, 1893, . .	"
Walpole, . . .	June 13, 1893, . .	"
Walpole, . . .	June 13, 1893, . .	"
Walpole, . . .	Sept. 7, 1893, . .	"
Dover, ...	June 3, 1893, . .	"
Upton, ...	July 31, 1893, . .	"
Upton, ...	July 31, 1893, . .	"
Westport, . . .	July 26, 1893, . .	"
Westport, . . .	July 26, 1893,	Plea of nolo contendere.
Millis, ...	Aug. 25, 1893, . .	Convicted.
Medfield, . . .	Aug. 25, 1893, . .	"
Medfield, . . .	Aug. 25, 1893, . .	"
Medfield, . . .	Aug. 25, 1893, . .	"
Norwood, . . .	Sept. 2, 1893, . .	"
Norwood, . . .	Sept. 7, 1893, . .	"
Norwood, . . .	Sept. 30, 1893, . .	"

For Fraudulent Sales of Milk — Concluded.

Place.	Date.	Result.
In Mendon,	Sept. 2, 1893,	Convicted.
Mendon,	Sept. 2, 1893,	"
Upton,	Sept. 2, 1893,	"
Upton,	Sept. 2, 1893,	"
Wrentham,	Sept. 25, 1893,	"
Provincetown,	Sept. 1, 1893,	"

Total, 61 cases.

For Fraudulent Sales of Butter.

In Boston,	Dec. 28, 1892,	Convicted.
Boston,	March 22, 1893,	"
Lowell,	Jan. 21, 1893,	"
Lowell,	Jan. 21, 1893,	"
Lowell,	Jan. 21, 1893,	"
Lowell,	Jan. 21, 1893,	"

Total, 6 cases.

OTHER ARTICLES OF FOOD.

Maple Syrup.

In Boston,	March 21, 1893,	Acquitted.
Fall River,	April 27, 1893,	Convicted.
Fall River,	May 4, 1893,	"

Maple Sugar.

In Boston,	April 19, 1893,	Convicted.
Boston,	April 19, 1893,	"

Honey.

In Boston,	Oct. 11, 1892,	Convicted.

Coffee.

In Boston,	Nov. 29, 1892,	Convicted.
Boston,	Dec. 15, 1892,	"
Boston,	March 21, 1893,	"
North Adams,	Oct. 20, 1892,	"
North Adams,	Dec. 17, 1892,	"
Hardwick (Gilbertville),	Oct. 31, 1892,	"

Molasses.

Place.	Date.	Result.
In Taunton,	Sept. 23, 1893,	Convicted.
Fall River,	June 20, 1893,	"
Fall River,	June 20, 1893,	"

Cassia.

In Fall River,	April 20, 1893,	Convicted.

Cloves.

In Hardwick (Gilbertville),	Oct. 31, 1892,	Convicted.
North Adams,	Dec. 17, 1892,	"

Pepper.

In Hardwick (Gilbertville),	Oct. 31, 1892,	Convicted.
Fall River,	April 20, 1893,	Acquitted.
Taunton,	Sept. 23, 1893,	Convicted.

Mustard.

In North Adams,	Dec. 17, 1892,	Convicted.
Boston,	March 21, 1893,	"
Gloucester,	Aug. 2, 1893,	"

Cream of Tartar.

In Hardwick (Gilbertville),	Oct. 31, 1892,	Convicted.
Boston,	Nov. 29, 1892,	"

Total, 26 cases.

DRUGS.

In Pittsfield,	Nov. 17, 1892,	Acquitted.
North Adams,	Nov. 10, 1892,	Convicted.
Boston,	April 7, 1893,	"

Total, 3 cases.

SUMMARY.

Complaints entered in court under the acts relating to inspection of milk and milk products,	67 cases.
Other articles of food,	26 "
Drugs,	3 "
Total,	96 cases.

Summary.

The whole number of complaints entered by the State Board of Health in the courts of the Commonwealth against parties for violation of the acts relating to food and drug inspection was 96. In 92, or 95.8 per cent. of these, the parties were convicted. Four were discharged, either in the lower or in the upper courts.

Of the foregoing cases, 61 were for violation of the laws relating to milk adulteration, of which number 60 resulted in conviction.

Nearly all of the cases entered for violation of the statutes relating to the sale of milk were entered under the statute which provides that milk offered for sale shall be of good standard quality, the standard being defined by law.

Six complaints were entered under the oleomargarine laws, each of which resulted in conviction.

There were also twenty-six complaints for fraudulent sales of other articles of food, in all of which except two the parties were convicted. In one of these, a complaint for fraudulent sale of maple syrup, it was claimed that the crate or wholesale package was marked with the word "compound," although the retail package had no such mark to indicate the character of its contents. This is only one of many instances which illustrate the difficulties which are liable to arise under the provision by which certain articles may be sold of an inferior quality, "provided that the same are not injurious to health, and are distinctly labelled as mixtures or compounds."

The articles of food embraced in the foregoing list were the following: —

Maple syrup, 3 cases; maple sugar, 2; honey, 1; coffee, 6; molasses, 3; cassia, 1; cloves, 2; pepper, 3; mustard, 3; cream of tartar, 2.

Of the samples of drugs which were the cause of complaints at court, one case was for refusal to furnish samples to an inspector; another was for a sale of a poisonous cosmetic; and the other was for a sale of McMunn's Elixir, which was not properly marked with a poison label, in compliance with the Statute of 1888 (chapter 209).

The standard of whole milk in Massachusetts is 13 per cent. of solid residue, except in the months of May and June, when it is 12

per cent. The following list presents the total solids in the samples of milk upon which complaints in court were founded: —

4.72	9.80	10.33	10.70	11.15
8.25	9.82	10.40	10.73	11.16
8.48	9.82	10.40	10.75	11.20
8.85	9.95	10.45	10.79	11.30
9.15	10.02	10.50	10.80	11.35
9.29	10.21	10.50	10.94	11.48
9.31	10.21	10.55	11.00	11.48
9.35	10.25	10.56	11.04	11.52
9.44	10.26	10.60	11.12	11.74
9.56	10.26	10.63	11.12	13.33

The total number of samples of food and drugs examined during the year was as follows: —

Milk,	3,224
Other articles of food,	3,009
Drugs,	327
Total,	6,560

Total expenses of collection, examination and prosecution,	$10,454 11
Average expense per sample collected,	1 59

Fines.

The amount of the fines paid into the treasuries of counties, cities and towns under the provisions of the general and special laws relative to the inspection of food and drugs was as follows: —

Fines paid for Violation of the Food and Drug Acts, upon Cases entered for the Year ending Sept. 30, 1893.

Under the provisions of the laws relating to milk and milk products,	$1,991 00
Under the provisions of laws relative to other articles of food,	459 00
Under the provisions of laws relative to drugs,	26 00
Total,	$2,476 00

Expenditures

Under the Provisions of the Food and Drug Acts during the Year ending Sept. 30, 1893.

	For the Enforcement of the Statutes relating to Food and Drug Inspection.	
	Relative to Milk and Milk Products.	Relative to Other Kinds of Food and Drugs.
Salaries of analysts,	$2,700 00	$1,700 00
Salaries of inspectors,	2,400 00	1,500 00
Travelling expenses and purchase of samples,	997 05	664 70
Apparatus and chemicals,	145 00	90 63
Rent at Harvard Medical School,	75 00	50 00
Chemical analysis (by other chemists),	-	2 00
Furniture and fittings at laboratory,	20 00	6 52
Legal services,	45 00	-
Printing,	4 85	-
Gas,	20 00	13 36
Extra services,	-	20 00
	$6,406 90	$4,047 21
		6,406 90
Total,	. . .	$10,454 11

SAM'L W. ABBOTT,
Secretary.

REPORT OF DR. C. P. WORCESTER, ANALYST.

REPORT OF DR. C. P. WORCESTER, ANALYST.

Dr. S. W. ABBOTT, *Secretary of the State Board of Health.*

DEAR SIR: — I have the honor to present my report on the analysis of food and drugs for the year ending Sept. 30, 1893.

The work during this year has been done in the room rented by the Board for the purpose, at 994 Washington Street. The laboratory has proved sufficient for the ordinary routine work, but for any investigation involving special apparatus its resources are too limited. The routine analysis this year has been similar to that of previous years.

MILK.

	Total Milks Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Lowest Sample.	Number of Skimmed Milks.
Cities,	1,931	1,001	930	48.1	7.42	13
Towns,	639	375	264	41.3	9.19	2
Suspected producers,	482	159	323	67.0	4.72	-
Miscellaneous,	21	10	11	52.4	-	-
Total milks,	3,073	1,545	1,528	49.7	4.72	15

The percentage of samples below standard is 49.7, practically the same as that of last year, which was 48.2 per cent.

The relative advantages of the various processes for the analysis of milk have been discussed at great length in the many text-books and in meetings of analysts the world over. For the purpose of determining the total solids there is no readier method that is reasonably accurate than the evaporation of a weighed quantity of milk over steam in flat-bottomed platinum capsules. The determination of the fat by benzine extraction of this dry residue has proved an

easy method, but it is accurate within rather wide limits, and there is an element of danger in the evaporation of large quantities of benzine in the laboratory.

These objections are met by the so-called Babcock process for the estimation of fat which we have adopted during this year. This process is too universally known and accepted to require any description. It depends upon the decomposition by sulphuric acid of the proteids of a measured quantity of milk and the subsequent separation of the clear fat in a form to be easily measured. The complete separation of the fat is accomplished by means of a centrifugal rotator.

The actual work involved in this process is but little more than in the benzine extraction, and the results are much more accurate. The accuracy of the process is universally admitted. In comparative analyses our experience has been that the fat by the Babcock method has always exceeded that found by the benzine extraction, while it closely agrees with the accurate but tedious "Adams process," in which a weighed quantity of milk is dried on a coil of c. p. filter-paper, and is subsequently treated with ether or benzine in a Soxhlet extraction apparatus.

The Babcock process is particularly useful in estimating the fat of skimmed or of sour milk, for the old benzine extraction of the dried solid residue in these instances has always been most unsatisfactory, since the residue is so hard and solid in the case of skimmed or sour milk that the fat solvent has difficulty in penetrating.

As in previous years the determination of fat has been confined to the poorer samples.

There have been found this year but few specimens of milk sophisticated with artificial coloring or preservatives. The color used in these cases was annatto; the preservative, boracic acid.

The following tables show in detail the result of the analysis of milk from the cities and towns of the State in which collections were made (excepting the four western counties), and also from suspected producers.

Milk from Cities.

Cities.	Total Milks Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Milks.
Boston,	175	111	64	36.6	11.24	1
Brockton,	12	7	5	41.7	11.51	-
Cambridge,	323	175	148	45.8	8.53	1
Chelsea,	131	61	70	53.4	8.62	6
Fall River,	101	67	34	33.6	9.35	-
Fitchburg,	24	7	17	70.8	9.40	-
Gloucester,	90	27	63	70.0	8.67	-
Lawrence,	24	15	9	37.5	9.99	1
Lowell,	12	9	3	25.0	12.03	-
Lynn,	141	46	95	67.3	7.42	1
Malden,	148	66	82	55.4	8.93	-
Marlborough,	8	7	1	12.5	12.63	-
Newton,	78	49	29	37.2	9.94	-
New Bedford,	26	18	8	30.8	11.17	-
Quincy,	24	9	15	62.5	10.50	-
Salem,	99	58	41	41.4	9.15	-
Somerville,	294	134	160	54.4	9.75	1
Taunton,	56	43	13	23.2	9.82	-
Waltham,	40	30	10	25.0	11.42	-
Woburn,	81	40	41	50.6	10.26	-
Worcester,	44	22	22	50.0	10.82	2
	1,931	1,001	930	48.1	7.42	13

Milk from Towns.

Towns.	Total Milks Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Total Solids in Lowest Sample.	Number of Skimmed Milks.
Adams,	12	10	2	16.6	12.11	-
Brookline,	83	48	35	42.2	11.83	-
Canton,	17	13	4	23.5	9.84	-
Dedham,	54	37	17	31.5	10.02	-
Everett,	57	29	28	49.1	10.40	-
Framingham,	6	4	2	33.3	11.32	-
Greenfield,	12	10	2	16.6	12.50	-
Hull,	13	4	9	69.2	10.00	-
Hyde Park,	59	27	32	54.2	10.40	-
Marblehead,	12	8	4	33.3	9.19	-
Medford,	72	30	42	58.3	9.38	-
Milford,	12	4	8	66.6	11.30	-
Natick,	24	21	3	12.5	12.39	-
Norwood,	21	13	8	38.1	9.81	2
Orange,	12	7	5	41.6	10.06	-
Plymouth,	4	1	3	75.	11.47	-
Provincetown,	40	29	11	27.5	9.28	-
Randolph,	10	10	0	0.0	13.40	-
Revere,	34	16	18	52.9	10.45	-
Stoneham,	16	6	10	62.5	11.30	-
Stoughton,	21	16	5	23.8	12.11	-
Wakefield,	5	3	2	40.	11.19	-
Wareham (Onset Bay),	13	9	4	30.7	12.08	-
Watertown,	13	5	8	61.5	10.35	-
Weymouth,	8	6	2	25.	12.35	-
Winthrop,	9	9	0	0.0	12.70	-
	639	375	264	41.3	9.19	2

Milk from Suspected Producers.

Suspected Producers.	Total Milks Collected.	Above Standard.	Below Standard.	Per Cent. Below Standard.	Total Solids in Lowest Sample.
Acton,	15	4	11	73.3	10.46
Berlin,	15	7	8	53.3	9.92
Billerica,	19	12	7	36.8	12.14
Brookfield,	5	0	5	100.	9.31
Carlisle,	5	1	4	80.	-
Charlton,	39	27	12	30.8	4.72
Chelmsford,	19	13	6	31.6	9.88
Concord,	4	0	4	100.	11.70
Dover,	12	6	6	50.	10.40
Framingham,	6	0	6	100.	9.86
Grafton,	12	0	12	100.	11.57
Holliston,	4	0	4	100.	10.04
Hopedale,	4	0	4	100.	9.71
Hopkinton,	8	4	4	50.	11.14
Lincoln,	15	5	10	66.6	11.50
Littleton,	22	5	17	77.3	11.43
Maynard,	6	0	6	100.	11.15
Medfield,	46	10	36	78.4	10.40
Medway,	3	2	1	33.3	12.58
Mendon,	13	4	9	69.2	10.21
Millis,	9	3	6	66.6	11.00
Norfolk,	3	3	0	0.0	13.49
Northborough,	12	5	7	58.3	11.88
Norwood,	28	11	17	60.7	10.63
Salisbury,	18	8	10	55.5	9.45
Shirley,	6	0	6	100.	11.31
Southborough,	5	3	2	40.	9.02
Sutton,	10	1	9	90.	9.29
Upton,	17	1	16	94.1	10.22
Waltham,	4	2	2	50.	12.52
Walpole,	21	4	17	80.9	8.48
Wenham,	11	2	9	81.8	10.33
Westborough,	34	4	30	88.2	11.35
Westport,	20	10	10	50.	10.94
Wrentham,	12	2	10	83.3	10.21
	482	159	323	67.0	4.72

The comparison of the quality of samples by months is of some interest in view of the efforts made to reduce the standard during the spring and summer months.

For this purpose the following tables have been prepared, showing the percentage of adulteration during the months of the preceding as well as of the present year, with both 12 and 13 per cent. assumed as a standard through the whole year: —

QUALITY OF MILK BY MONTHS. YEAR ENDING SEPT. 30, 1892.

Months.	Total Milks Collected.	Above 13 Per Cent.	Below 13 Per Cent.	Below 12 Per Cent.	Per Cent. of Adulteration, 13 Per Cent. Standard.	Per Cent. of Adulteration, 12 Per Cent. Standard.
October,	305	154	151	42	49.5	13.7
November,	197	104	93	25	47.2	12.6
December,	142	81	61	16	42.9	11.2
January,	163	102	61	8	37.3	4.9
February,	240	119	121	30	50.4	12.5
March,	239	98	141	44	59.	18.4
April,	336	151	185	49	55.	14.6
May,	293	125	165	43	56.3	14.6
June,	254	91	162	48	63.8	16.9
July,	253	89	164	64	64.8	25.2
August,	238	68	170	42	71.4	17.6
September,	359	128	231	63	64.3	17.5
Average,	-	-	-	-	55.2	15.

QUALITY OF MILK BY MONTHS. YEAR ENDING SEPT. 30, 1893.

Months.	Total Milks Collected.	Above 13 Per Cent.	Below 13 Per Cent.	Below 12 Per Cent.	Per Cent. of Adulteration, 13 Per Cent. Standard.	Per Cent. of Adulteration, 12 Per Cent. Standard.
October,	272	146	126	28	46.3	10.3
November,	304	187	117	37	38.4	12.1
December,	260	117	143	49	55.	18.8
January,	111	51	60	17	54.	15.3
February,	109	37	72	25	66.	22.9
March,	231	103	128	40	55.4	17.3
April,	257	120	137	50	53.2	19.4
May,	250	85	165	60	66.	24.
June,	294	94	200	32	68.	10.9
July,	298	91	207	85	69.4	28.5
August,	423	134	289	122	68.3	28.8
September,	264	107	157	41	59.5	15.5
Average,	-	-	-	-	58.5	18.6

Condensed Milk.

Samples of condensed milk and so-called "evaporated cream" were analyzed for total solids and fat with the following results, the fat being obtained by benzine extraction: —

Inspectors' Number.	Brand.	Character of Sample.	Per Cent. Solids.	Per Cent. Solids not Fat.	Per Cent. Fat.	Per Cent. Water.
13570	St. Charles,	Evaporated cream,	31.87	26.83	5.04	68.13
13572	Highland,	" "	31.60	25.70	5.90	68.40
1024	St. Charles,	" "	31.09	26.74	4.35	68.91
15431	Baby,	Condensed milk,	67.20	59.70	7.50	32.80
1988	J. B. Smith,	" "	75.43	63.65	11.78	24.57
8405	Newport,	" "	68.32	61.10	7.22	31.68
83	Puritan,	" "	78.35	68.	10.35	21.65
127	Maine Jersey,	" "	69.02	62.75	6.27	30.98
1063	Full Weight,	" "	74.45	67.16	7.29	25.55
1935	Sovereign,	" "	71.75	65.00	6.75	28.25
2199	Winner,	" "	68.00	62.00	6.00	32.00
2833	Fisherman's,	" "	69.10	63.07	6.03	30.90
2613	Champion,	" "	74.20	65.50	8.70	25.80
2875	Twitchel Champlin Co.,	" "	72.20	59.80	12.40	27.80
3123	Dime,	" "	72.10	60.00	12.10	27.90

Cheese.

Seventy-three samples of cheese have been examined and no case of fraudulent adulteration has been found. A series of forty-one samples were obtained at different times from the poorer quarters of Boston, and were analyzed immediately after purchase, before any appreciable loss of water by evaporation could take place, with the following results: —

Inspectors' Number.	Per Cent. Solids.	Per Cent. Fat.	Per Cent. Solids Not Fat.	Per Cent. Water.	Per Cent. Fat in Total Solids.	Price per Pound.
						Cents.
5241	66.04	38.	28.04	33.96	57.54	17
5239	66.06	37.	29.06	33.94	56.01	16
5237	62.36	26.	36.36	37.64	41.69	10
5235	66.18	34.	32.18	33.82	51.22	18
5233	66.00	35.	31.00	34.00	53.03	16

Inspectors' Number.	Per Cent. Solids.	Per Cent. Fat.	Per Cent. Solids Not Fat.	Per Cent. Water.	Per Cent. Fat in Total Solids.	Price per Pound.
						Cents.
5231	68.14	38.	30.14	31.86	55.77	16
5229	62.14	32.	30.14	37.86	51.49	16
5227	66.60	35.	31.60	33.40	52.55	16
5325	64.19	34.	30.19	35.81	52.97	16
5327	67.26	37.	30.26	32.74	55.01	16
5331	66.76	35.	31.76	33.24	52.41	16
5333	66.24	37.	29.24	33.76	55.85	16
5335	68.84	38.	30.84	31.16	55.20	18
5323	64.32	35.	29.32	35.68	54.41	16
5821	60.36	35.	25.36	39.64	57.98	16
5815	72.30	37.	35.30	27.70	51.17	16
5817	60.40	34.	26.40	39.60	56.29	16
5819	65.00	36.	29.00	35.00	55.38	16
5811	63.72	35.	28.72	36.28	54.92	16
5809	70.12	37.	33.12	29.88	52.76	16
5813	70.37	32.	38.37	29.63	45.47	16
5827	69.10	39.	30.10	31.90	56.44	16
5825	72.52	40.	32.52	28.48	55.15	16
5829	68.93	38.	30.93	31.07	55.13	16
5831	62.88	36.	26.88	37.12	57.23	16
5837	59.43	35.	24.43	40.57	58.89	16
5835	62.09	32.	30.09	37.91	51.53	16
5833	55.89	29.	26.89	44.11	51.89	16
5839	67.92	40.	27.92	32.08	58.89	16
5903	67.94	35.	32.94	32.06	51.51	16
5889	70.49	32.	38.49	29.51	45.39	16
5895	70.31	37.	33.31	29.69	52.62	16
6573	69.99	39.	30.99	30.01	55.72	16
5901	69.83	36.	33.83	30.17	51.55	16
5897	69.14	36.	33.14	30.86	52.05	16
5899	69.01	27.	42.01	30.99	39.12	16
5329*	44.43	3.	41.43	55.57	6.75	14
5337†	44.26	26.	18.26	55.74	58.74	-
5339‡	61.30	45.	16.30	38.70	73.49	20
17279†	44.70	5.2	39.50	55.30	11.63	-
Average,§	66.85	35.	31.35	33.65	52.75	-

* Skimmed milk cheese.
† Neufchatel cheese.
‡ Cream cheese.
§ Average is exclusive of last four samples.

It will be noticed that with few exceptions the uniform retail price of whole-milk cheese was found to be sixteen cents per pound. The exceptions were the skimmed-milk cheeses and remnant lots of poor quality which were cheaper and the extra cream cheeses which were more expensive. This means two-thirds of a pound of milk solids for sixteen cents, or one pound for twenty-four cents. Now, twenty-four cents will buy at retail, as a rule, four quarts of standard milk, which contain approximately one pound of milk solids. Weight for weight, then (water excluded), cheese and milk are sold practically at the same rate. It should be added, however, that nearly one-third of the milk solids is sugar, a much cheaper element of food than the fat and proteids which are in greater proportion in cheese. The percentage of fat determined by the Babcock process in terms of solids averaged 53 per cent., a somewhat high ratio. Of standard milk the fat is 28 per cent. in terms of the solids, the smaller ratio being due chiefly to the excess of sugar in the milk solids.

Butter.

In but one instance has the fraudulent substitution of oleomargarine for butter been found. Four hundred and seventeen samples of butter have been analyzed and twenty-four of oleomargarine.

Bread.

Fifty-nine samples of bread, chiefly of cheap white bread, were collected from the poorer classes of bakeries and grocers' shops in order to ascertain what sort of bread is furnished to the poorer classes who usually depend on the "corner grocery" for their supply.

Inspection showed, as a rule, loaves which were not far from the standard "home-baked family loaf." They showed, as a rule, a thorough baking, though there were not a few exceptions to this rule; they were well "raised," had a good crumbling fracture, were not tough and soggy, nor, on the other hand, were they over-raised, with a dry and spongy texture. The majority had the sweet, agreeable odor and taste described as the "nutty flavor" characteristic of a well-made loaf. In a number of instances, however, there was distinctly perceptible a musty flavor, amounting in some cases to a downright sour odor and taste. This sourness seems, at least in part, to be due to a bacterial growth attended by

the production of lactic acid or of acid salts. At what stage in the process of manufacture this incipient decomposition has taken place it is impossible to determine without a careful investigation of each step in the process of making every loaf.

The souring of bread may usually be traced to poor materials or to uncleanness in the manufacture. Chief among the unsound materials which may contribute toward this sourness are usually noted damaged flour and decomposing yeast. So far as has been investigated the use of unsound flour is not practiced in this part of the country. The yeast generally used is of excellent quality. It is a stiff, smooth mash, put up usually in small tin-foiled cakes, and kept in a cool place. Under the microscope this mash is seen to be composed of about equal parts of potato or corn starch and yeast spores. It has a distinct yeasty odor, and but rarely is it strongly acid in reaction. To the almost universal use of good sweet yeast of this variety in the small bakeries is doubtless due no small share in the great improvement in quality of the common baker's loaf of to-day as compared with that of ten or more years ago.

A vigorous, pure yeast which will "raise" quickly is a great preventive against sour bread, for not only is it comparatively free from the germs and products of lactic acid decomposition, but by doing its work quickly it enables the baker to check the fermentation or "raising" process before the lactic acid or sour decomposition is reached.

The degree of sourness of the samples of bread examined has been roughly measured and compared by titrating or neutralizing 10 grammes of the crumb, rubbed up with water, with a decinormal soda solution. To neutralize the acidity of 10 grammes of the normally sweet loaf an average of 2 cubic centimeters of the soda solution was required. This would correspond to 0.72 grammes of lactic acid per loaf of an average weight of about 400 grammes. The loaf exhibiting the maximum sourness or acidity required 10 cubic centimeters per 10 grammes of bread corresponding to 11.61 grammes of lactic acid per loaf of 1,291 grammes.

The so-called black bread (rye bread), which finds a ready sale among our foreign population, is notably sour and heavy, and apparently its sourness is valued by this class. A sour bread is undesirable, not only because it is unpalatable but also because of the bacterial processes of decomposition which this acidity indicates, and which may seriously interfere with digestion.

Bread.

Inspectors' Number.	Weight of Loaf in Grammes.	Percentage of Water.	Percentage of Solids.	Percentage of Ash in Terms of Solids.	Acidity. Cubic Centimeters of Soda Solution Required to Neutralize 10 Gms. Fresh Bread.	Price of Loaf in Cents.	Description.
4761 . . .	480	42	58	1.03	2.5	5	White.
4763 . . .	434	33	67	1.10	2.7	5	White.
4765 . . .	340	43	57	0.60	2.2	5	White.
4793 . . .	580	41	59	0.90	2.7	10	White.
4795 . . .	-	43	57	1.30	3.0	5	White.
4899 . . .	417	42	58	0.95	-	5	White, with caraway seed.
6245 . . .	390	45	55	1.90	2.6	5	White.
6253 . . .	457	43	57	0.92	-	5	White.
6247 . . .	373	40	60	1.44	4.8	4	White, over-raised, dry and spongy.
6249 . . .	387	39	61	1.94	-	5	White, over-raised.
6251 . . .	408	42	58	1.18	3.5	5	White.
6253 . . .	400	41	59	1.23	1.8	5	White, from "N. E. kitchen."
6691 . . .	464	42	58	0.68	-	5	White, underdone.
6693 . . .	410	44	56	1.05	-	5	White.
6695 . . .	387	43	57	1.40	3.3	4	White, over-raised, spongy.
6697 . . .	481	43	57	0.83	3.3	5	White.
6699 . . .	450	42	58	1.09	3.0	5	White.
6701 . . .	387	41	59	1.16	1.9	5	White, "milk loaf."
6703 . . .	320	42	58	1.40	2.1	4	White.
6705 . . .	502	43	57	1.83	6.2	4	White, glazed roll loaf, tough and sour.
6707 . . .	415	43	57	0.65	1.3	5	White, underdone.
6709 . . .	450	43	57	0.85	1.4	5	White, underdone
6713 . . .	495	42	58	0.95	1.7	5	White, "shortened."
6715 . . .	422	42	58	1.27	-	5	White.
6717 . . .	415	42	58	1.00	-	5	White.
6719 . . .	654	44	56	1.00	1.8	10	White, "milk loaf."
6721 . . .	420	42	58	1.15	1.8	5	White.
6723 . . .	547	39	61	0.85	3.2	5	White, over-raised, underdone.
6725 . . .	422	42	58	0.92	2.1	5	White.
6727 . . .	382	42	58	0.80	1.7	5	White.
6511 . . .	264	44	56	0.85	1.4	4	White, "French loaf."
6509 . . .	461	41	59	0.64	2.4	5	White.
6507 . . .	441	42	58	0.60	1.9	5	White, underdone.
6505 . . .	653	44	56	1.60	7.0	6	White, yellowish, sour.

Bread — Concluded.

Inspectors' Number.	Weight of Loaf in Grammes.	Percentage of Water.			Acidity. Cubic Centimeters of Soda Solution Required to Neutralize 10 Gms Fresh Bread.	Price of Loaf in Cents.	Description.
6503	422	42	58	0.75	3.0	6	White.
6501	420	43	57	1.00	1.9	5	White, underdone.
6499	128	41	60	1.17	2.5	6	White.
6497	194	43	57	1.65	2.0	6	White.
6495	454	43	57	0.77	1.9	6	White.
6493	433	43	57	0.80	3.0	5	White.
6491	448	42	58	0.97	3.0	5	White.
6489	418	42	58	1.10	2.5	6	White, "French roll."
6611	477	42	58	1.60	3.1	5	White, soggy.
6613	482	44	56	0.95	1.9	6	White, underdone.
6515	376	[illegible]	59	1.25	4.2	5	Graham.
6513	416	43	57	1.04	2.1	5	Graham.
6517	407	40	60	1.46	[illegible]	5	Graham.
6519	367	40	60	0.96	3.6	5	Graham, over-raised, spongy.
6711	455	[illegible]	58	1.55	2.2	6	Graham.
5423	500	45	56	1.46	-	10	Graham.
4899	445	40	60	1.10	3.5	5	Graham.
5425	507	45	55	1.20	-	10	Whole wheat bread.
5429	445	47	53	2.20	-	10	"Diabetic" bread.
4910	194	48	52	1.15	1.7	5	"Muffins."
4750	1291	47	53	2.18	10.0	8	"Black bread" (rye).
5427	550	47	53	2.20	-	10	"Black bread."
4909	417	42	58	0.95	-	5	"Seed bread."
5421	500	48	52	3.50	-	10	Brown bread.
5429	110	8	92	1.94	-	10	"Knacker-brod."

Average weight of loaf of white bread is 404 grammes. Usual price is five cents. Average percentage of water of crumb is 42 per cent.

Spices.

The microscopic examination of over 1,400 samples of ground spices resulted in the discovery of 189, or 14 per cent. of adulterated samples.

Allspice.

Adulteration, 5 per cent. Adulterants found were wheat, corn, ginger and nut shells.

Cassia.

Adulteration, 7 per cent. Adulterants found were ginger, bark of some variety, wheat, pease, sawdust and nut shells. The worst specimen contained 75 per cent. of wheat.

Cayenne.

Adulteration, 38 per cent. Adulterants found were corn, wheat, ginger, nut shells and turmeric. The worst specimen contained 90 per cent. of wheat, corn, turmeric and cocoanut shells. Many of these samples were purchased as "capsicum" from drug stores, and in these instances the percentage of adulteration was higher than the average.

Cloves.

Adulteration, 13 per cent. Adulterants found were corn, wheat, allspice, nut shells, pease, ginger, pepper, charcoal, dirt, turmeric and clove stems. The worst specimen contained 70 per cent. of nut shells, pease and ginger.

Ginger.

Adulteration, 7 per cent. Adulterants found were corn, wheat, rice and turmeric. The worst specimen contained 40 per cent. of corn and turmeric.

Mace.

The only adulteration found was the apparently accidental admixture of other spices in one instance.

Mustard.

Adulteration, 27 per cent. Adulterants found were wheat, corn, rice, cayenne, mustard hulls, tapioca and turmeric, the latter being added for color both in the ground form and in the form of an extract. The worst specimen contained but a small trace of mustard, the other constituents being the first four of the above-named adulterants, colored with turmeric.

Nutmeg.

No adulteration found.

Pepper.

Adulteration, 11 per cent. Adulterants found were wheat, buckwheat, corn, sawdust, cayenne, nutshells and charcoal. The worst specimen contained 90 per cent. of wheat, buckwheat and cayenne.

Baking Powder.

Of eight brands of baking powder examined, six contained alum.

Canned Goods.

Of nineteen samples of canned goods of various kinds, none were found to contain any harmful preservative or metallic poison.

Chocolate.

No adulteration was found in the five samples submitted.

Confectionery.

Of the fifty-nine samples examined, all but two were composed of edible and non-injurious constituents, such as cane sugar, glucose, and wheat, corn and potato starch. Two samples contained paraffin in considerable amount and turpentine, which was added doubtless under the name of "Essence of Lemon."

Coffee.

Adulteration, 30 per cent. Adulterants found were chicory, pease, wheat, wood, charcoal and dried grains composed of ground pea hulls and molasses. The worst case of adulteration contained 50 per cent. of pease and chicory, while a "compound coffee" was found to contain no coffee whatever. A coffee substitute and adulterant was found to consist of small brown pellets of about the size of coffee beans, but composed of wheat mash, mixed with a red oxide of iron for a color, and roasted.

Cream of Tartar.

Adulteration, 3 per cent. Adulterants found were gypsum, corn starch and phosphate of calcium. The adulteration of cream of tartar is now comparatively rare. The worst sample contained 75 per cent. of calcium phosphate and corn, while a "compound cream of tartar" was found to contain no cream of tartar whatever.

Honey.

Adulteration, 14 per cent. The only adulterant found was glucose syrup, which was found in varying amounts up to 40 per cent. The analysis of honey, sugars and syrups is made by means of the polariscope.

Molasses.

Adulteration, 11 per cent. The only adulterant found was glucose syrup, which was present in one instance to the extent of 40 per cent.

Maple Syrup.

Adulteration, 43 per cent. Adulterants found were cane sugar other than maple and glucose. The worst specimen was a so-called "Vermont Maple Syrup," containing 58 per cent. of glucose syrup.

Maple Sugar.

Adulteration, 34 per cent. The adulterant found was a crude molasses sugar, which chemically is nearly identical with maple sugar, but whose flavor is totally different.

Syrup.

Only one sample of the fifteen submitted was found to be adulterated, but that contained 50 per cent. of glucose.

Lard.

Adulteration, 28 per cent. The adulterants found were cottonseed oil and tallow.

Tea.

None was found to contain other than genuine tea leaves, and but one sample contained too much mineral matter indicating spent leaves. The rigid examination of teas at various ports of entry by government inspectors regularly appointed for that purpose has resulted in practically shutting out spurious teas from our market.

Vinegar.

Adulteration, 34 per cent. Any failure to conform to the legal standard of 4.5 per cent. of acetic acid and 2 per cent. of apple solids constitutes adulteration. Samples may contain too little acetic acid

either from insufficient fermentation of the cider or from dilution with water. An insufficiency of apple solids indicates watering, and the substitution of other solids indicates that the vinegar is made at least in part by the fermentation of materials other than cider,— notably molasses. The greater number of adulterated samples fell but slightly below the standard.

Olive Oil.

Adulteration, 26 per cent. The adulterant found was cotton-seed oil. Many of the cotton-seed oil substitutes for olive are now labeled "sweet oil" or "salad oil," terms of such an indefinite significance that technically there is no deception.

Miscellaneous.

Of 116 samples of a miscellaneous description 24 were found not of good quality. Of this number were samples of *pickles* containing notable quantities of alum; *dried apples* containing considerable traces of zinc; *catsup* containing salicylic acid; *fruit syrups* containing salicylic acid, in some instances to the extent of 0.47 per cent.; *salt fish* preserved with boracic acid.

Among the novelties of this class was a sample of "kustard" which proved to be a mixture of corn starch and salt flavored with coumarin.

Summary of Food Statistics.

	Genuine.	Adulterated.	Total.		Genuine.	Adulterated.	Total.
Allspice,	92	5	97	Honey,	46	8	54
Baking powder,	2	6	8	Lard,	15	6	21
Bread,	59	0	59	Mace,	56	1	57
Butter,	417	24	441	Maple sugar,	28	15	43
Canned goods,	19	0	19	Maple syrup,	17	13	30
Cassia,	185	14	199	Miscellaneous,	116	24	140
Cayenne,	40	25	65	Molasses,	136	17	153
Cheese,	73	0	73	Mustard,	174	64	238
Chocolate,	5	0	5	Nutmeg,	2	0	2
Cloves,	190	28	218	Olive oil,	17	6	23
Coffee,	49	21	70	Pepper,	289	36	325
Confectionery,	59	2	61	Syrup,	14	1	15
Cream of tartar,	353	13	366	Tea,	59	1	60
Ginger,	193	16	209	Vinegar,	58	31	89

Drugs.

Of this class, 327 samples were examined. Ninety-nine proved to be not of Pharmacopœal quality.

Acidum Benzoicum: 3 standard.

Acidum Hydrobromicum: 2 standard.

Acidum Tannicum: 15 standard; 1 inferior, containing a resin insoluble in water.

Æther: 6 standard; 2 inferior, containing too much alcohol.

Æther fortior: 3 standard.

Alcohol: 15 standard.

Aqua Ammoniæ: 5 standard; 2 inferior, containing too much water.

Aqua Ammoniæ fortior: 5 standard.

Aqua Destillata: 1 standard.

Bismuthi Subnitras: 2 standard.

Cerii Oxalas: 2 standard.

Chloroform: 3 standard.

Extractum Glycyrrhizæ: 1 standard; 2 inferior, containing considerable amounts of corn and wheat starch.

Extractum Malti: 1 of good quality.

Ferri et Quininæ Citras: 7 not of the Pharmacopœal standard.

Glycerinum: 16 standard; 3 inferior, containing oils reducing nitrate of silver, one sample containing petroleum.

Iodoform: 1 standard.

Lycopodium: 2 standard.

Liquor Magnesii Citratis: 2 standard.

Magnesii sulphas: 1 standard.

Oleum Olivæ: 9 of good quality; 2 cotton-seed oils.

Opii Pulvis: 10 standard, 2 inferior, containing too little morphine.

Potassii Acetas: 5 standard; 3 inferior, containing considerable carbonate and chloride.

Potassii Citras: 6 standard.

Potassii Iodidum: 6 standard; 1 inferior, containing a considerable amount of chloride.

Potassii Permanganas: 6 standard.

Pulvis Effervescens Compositus: 13 standard in quality, but of considerable variety of weight, and the blue and white papers transposed in two instances.

Pulvis Glycyrrhizæ Compositus: 1 of inferior quality.

Pulvis Rhei: 9 standard.

Quininæ Bisulphas: 1 standard.

Quininæ Sulphas: 7 standard.

Spiritus Frumenti: 2 standard; 1 inferior, containing too much solid matter, chiefly sugar. The percentage of alcohol varied from 41 to 53.

Spiritus Juniperi: 2 of good quality and 2 inferior, being largely diluted with water.

Spiritus Limonis: 1 standard.

Spiritus Vini Gallici: 2 standard.

Sulphur Lotum: 12 standard; 1 inferior, containing 50 per cent. of gypsum.

Syrupus: 1 standard; 1 inferior, containing too much water.

Tinctura Aconiti: 6 standard.

Tinctura Iodi: 3 standard; 10 inferior, containing too little iodine, the deficiency being from 5 to 30 per cent.

Tinctura Nucis Vomicæ: 4 standard; 5 inferior. This tincture should contain 2 per cent. of the dry extract. The samples submitted contained from 2.19 per cent. to 0.6 per cent.

Tinctura Opii: 25 standard; 27 inferior. This tincture should contain 1.3 to 1.5 per cent. of morphine by the Pharmacopœal assay. The samples submitted contained from 2.19 per cent. to 0.66 per

cent., the strongest tincture being more than three times as strong as the weakest.

Vinum Album: 4 samples not of Pharmacopœal quality, containing too much solid residue, chiefly sugar. The alcohol also was found to be from 1 to 3 per cent. in excess.

Vinum Rubrum: 16 samples not of Pharmacopœal quality. Here again there proved to be a large excess of sugar, while the alcohol varied from 2 per cent. below to 3 per cent. above the standard.

Zingiber: 1 standard.

Miscellaneous: 12 of good quality; 1 not of good quality. In this class were included samples of non-poisonous insect fluids composed of benzine, alcohol, peppermint, pennyroyal and borax.

A "wild cherry beverage" contained no hydrocyanic acid.

A sample of patent obesity pills contained nothing to be detected but sugar.

A sample of "freckle lotion" contained forty grains of corrosive sublimate per bottle.

Other face washes selling at one or two dollars per bottle were found to contain alcohol and citric acid in solution, and sulphur, chalk and gypsum in suspension.

A sample of "Black Pepsin" was found to consist of ground annatto and salt. It gave a slight pepsin digestion reaction.

A sample of "Compound Extract of Salix," prepared for preserving eggs, fruit and vegetables, proved to be salicylic acid.

SUMMARY.

	Genuine.	Adulterated.	Total.
Milks,	1,545	1,528	3,073
Foods not milk,	2,763	377	3,140
Drugs,	228	99	327
Totals,	4,536	2,004	6,540

Respectfully submitted,

CHARLES P. WORCESTER.

PROFESSOR GOESSMANN'S REPORT.

The following report comprises the results of the analyses of samples of milk obtained in the four western counties of Massachusetts during the year ending Sept. 30, 1893.

The whole number examined was 187, of which 38, or 20.3 per cent., were below the standard. This result was but slightly greater than that of 1892 for the same district, which was 19.8 per cent.

The results of analyses were as follows: —

Whole number examined,	187
Number above standard,	149
Number below standard,	38
Percentage below standard,	20.3
Samples of skimmed milk,	7

The statistics of the cities are as follows: —

CHICOPEE.

Number of samples,	16
Number above standard,	14
Number below standard,	2
Percentage below standard,	12.5
Skimmed milk,	2

HOLYOKE.

Number of samples,	16
Number above standard,	16
Number below standard,	0
Percentage below standard,	0
Skimmed milk,	2

PITTSFIELD.

Number of samples,	15
Number above standard,	9
Number below standard,	6
Percentage below standard,	40.0
Skimmed milk,	0

SPRINGFIELD.

Number of samples,	37
Number above standard,	28
Number below standard,	9
Percentage below standard,	24.3
Skimmed milk,	0

The results in the towns were as follows: —

	Total.	Above Standard.	Below Standard.	Percentage below Standard.
Adams,	13	12	1	-
Greenfield,	12	10	2	-
Lee,	8	5	3	-
North Adams,	42	34	8	-
Orange,	12	7	5	-
Ware,	16	14	2	-
	103	82	21	20.4

C. A. GOESSMANN,
Chemist.

AMHERST, MASS.

ISOLATION HOSPITALS FOR INFECTIOUS DISEASES.

ISOLATION HOSPITALS FOR INFECTIOUS DISEASES.

By S. W. Abbott, M.D., Secretary of the Board.

An increased demand, during the past two years, from the authorities of cities and large towns, and especially from manufacturing towns, for information on the subject of infectious disease hospitals has formed the incentive to the compilation of the following paper.

The essential difference between hospitals established for receiving patients attacked with infectious disease and other hospitals consists in the fact that the latter, the general hospitals, are maintained mainly for the purpose of affording care and treatment for the individual, while the former, the infectious disease hospitals, in affording this care and treatment also provide for the protection of the community at large, and thus constitute one of the essential measures for preventing the spread of infectious diseases by furnishing the means for isolating the first cases which appear in any community.

The principal reasons for providing these establishments in large cities are the following: —

First. Isolation constitutes the first and essential principle in the preventive treatment of the majority of infectious diseases. The more perfect the barrier between the sick and the well the greater becomes the certainty of staying the spread of infectious disease. On the other hand, the increasing accumulation of our population in the cities has a tendency to favor the spread of such disease. The urban population of Massachusetts (*i. e.*, people living in cities having more than 8,000 inhabitants in each), was only 27.1 per cent. of the total population of the State in 1840. In 1880 it had increased to 58.4 per cent., and in 1890 to 69.9 per cent. The urban population of the United States had also increased from 22.6 per cent. in 1880 to 29.1 per cent. in 1890.

To illustrate the effect which this crowding together of the population has upon the mortality from infectious diseases the following data are presented. They are the result of observations upon this subject extending over a period of twenty years in Massachusetts,

and were published in the twenty-third annual report of the State Board of Health, page 783, etc. They are here more conveniently grouped together in one table.

Mortality from Eight Principal Infectious and Destructive Diseases in Dense, Medium and Sparsely Settled Districts in Massachusetts, that of Dense Districts being taken as 1,000.

	MORTALITY FROM								
	All Causes.	Measles.	Scarlet Fever.	Diphtheria and Croup.	Small-pox.	Cholera Infantum.	Consumption.	Pneumonia.	Typhoid Fever.
Dense, . .	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Medium, . .	826	517	818	780	332	898	810	792	1,109
Sparse, . .	760	445	587	634	149	639	727	783	1,175

In using these terms, *dense* refers to those districts in which there was less than one acre to each inhabitant; *medium*, to those districts in which there was more than one acre but less than four acres to each inhabitant; and *sparse*, to those districts in which there were more than four acres to each inhabitant. By this table it appears that overcrowding has an unfavorable effect upon the mortality of each one of the foregoing diseases except typhoid fever.

Secondly. The inability of the majority of laborers and mechanics to furnish separate accommodations for the isolation of members of their families who may become ill with infectious disease is well known. Such families usually live in tenements having from one to four rooms, none of which can safely be devoted to the treatment and isolation of infectious diseases of a dangerous character. The serious overcrowding which prevails in some of the large cities of Great Britain has not yet been reached in any of our large cities, but the tendency is in that direction (Glasgow has a population of more than 100,000 living in one-room tenements). The very great increase of the population of this class by immigration has been the chief factor in causing overcrowding in our cities during the past decade.

Third. Another important advantage secured by the isolating hospital is found in the fact that the ordinary duties of the household, the attendance at school, and especially the support of the family by its wage-earners, can be carried on without disturbance, the danger of infection having been removed by the transfer of the sick member of the family to the hospital. It has not unfrequently happened that the local sanitary authorities in some of our cities and

towns have not only rigorously enforced the law relating to non-attendance at school, but have also quarantined the whole family, old and young; so that, by this means, the scholar is deprived of from two to ten weeks, or even more, of his educational privileges at the most important or most receptive period of his life, the length of time depending upon the duration of illness in the infected household; and more than this, the father and other wage-earners have been kept from work in the mill, the factory or the workshop. Even if he is allowed to work, his fellow workmen are wont to regard him with suspicion so long as a case of any one of the infectious fevers exists in his household. Now, the prompt removal of such cases permits the school attendance and the employment of other members of the family to go on undisturbed.

In all my experience with local boards of health during the past few years, I know of no circumstance or condition which has given more serious trouble and perplexity than this, nor do I know of any which is likely to be relieved to so great an extent as is this condition by the introduction of the isolating hospital.

So far as one disease (small-pox) is concerned, the principle of isolation in a hospital specially provided or designed for such purpose has been recognized from a very early period of our history. In 1701 an act was passed by the General Court "for the better preventing the spread of infection," wherein it was provided that "when persons were visited with the plague, small-pox or pestilential or malignant fever, and other contagious sickness, the infection whereof may be communicated to others," the selectmen were empowered to remove such infected persons to separate houses, and to provide "nurses, tendance and other assistance and necessaries for them, at the charge of the parties themselves, their parents or masters (if able), or otherwise at the charge of the town or place where they belong."

Small-pox has been shorn of much of its terrors by the discovery and practice of vaccination, so that while in the last century it furnished a very large percentage of the deaths the ratio of such mortality in the present century has been very greatly diminished.

The number of deaths from small-pox in the twenty years (1871–1890) in Massachusetts was 2,298, while those from measles, scarlet fever, diphtheria, croup and typhoid fever were, respectively, 3,984, 14,639, 36,553 and 19,421. If the ratio of cases to deaths maintained the average which has usually been observed, the total number of cases of these diseases which occurred in the State during

these twenty years must have been at least 700,000. Had adequate provision been furnished for controlling epidemics at their outset, it is safe to say that a very considerable portion of these lives, and also of these cases of illness, might have been saved. The provision of isolating hospitals constitutes one important measure for controlling such epidemics, while prompt notification by the attending physicians, disinfection, vaccination and restriction of school attendance from infected families also constitute a part of the same general plan of action.

Hospitals for infectious diseases have reached their highest type of development in England, but are not yet in very common use in the continental countries of Europe. In commenting upon the history of this subject, Dr. Buchanan says, in his introduction to the special report to the Local Government Board of England upon the "Use and Influence of Hospitals for Infectious Diseases": —

The original design of these hospitals in England was to promote the recovery of the individual poor patient for whom other accommodation was wanting; indeed, the name "house of recovery" was a frequent synonym for infectious disease hospital at the period when such an institution was first seen to be necessary. But it was inevitable that the advantages to be obtained by the district possessing a hospital should soon force themselves upon the attention of the observer, and from a very early period of their history infectious disease hospitals have been advocated on the ground of their protecting the household against the spread of infection.

The benefits of these hospitals were not, however, obtained without a good deal of misfortune within the walls of the institutions themselves. In the small-pox hospital, indeed, this was not apparent. Small-pox had been regarded from the beginning as requiring a special building for itself. It had a "specific" contagion, which could not be safely treated under the same roof with the "general" contagion of fever. So, in the hospital where no disease but small-pox was received, patients had no opportunity of contracting other diseases. The nurses, in early times selected from among those who had passed through an attack of small-pox, and in later times, having their vaccination specially cared for, took nothing from their patients; but in the "fever hospital" the case was different. Doctors and nurses caught fever, in some years more than in others, while convalescent patients had what appeared to be repetitions of fever attacks. So serious indeed did these misadventures become that forty years ago it had come to be spoken of as doubtful whether fever cases, if they were to be treated in hospitals at all, had not better be distributed through the wards of general hospitals. The experiment was tried, but with far greater disaster to the patients and attendants of the general hospital.

In the foregoing quotation the special form of fever to which reference is made is undoubtedly typhus, and not typhoid or enteric fever.

With reference to the propriety of separating isolating hospitals absolutely from all other establishments, Dr. Rowe says in his recent paper upon this subject: —

> In large communities the only system that is beyond criticism is to make for infectious diseases a separate establishment, independent and isolated. . . . It is the duty of hospital workers and sanitarians not to cease forcing upon public authorities the necessity of intelligent action, until every municipality, through its public treasury, shall provide special hospitals always available for infectious diseases. Is it not the wisest policy to put such hospitals under the immediate control of the local board of health? They have so close a connection with other vital matters properly belonging to health boards that it conduces to unity of action to have the suppression of infection under one authority, a practice that obtains in Great Britain.*

As early as 1866 an act of Parliament had given to local authorities the power to erect and to maintain hospitals for isolation of persons suffering with contagious diseases. This power was further enlarged by the general Public Health Act of 1875. As a result of this legislation it was found by returns made in 1879 that 296 authorities had availed themselves of this privilege in the erection of buildings of one sort or another for this specific purpose. The arrangements were in some cases rudimentary and insufficient, and on the other hand some authorities had wisely and liberally used their powers in providing efficient hospitals for the reception of persons suffering with contagious fevers and from small-pox.

In a brief paper upon the same subject presented at the International Congress of Hygiene at London in 1891, Dr. Thorne states that this number had increased to 400, and that the general adoption of the provisions of the Infectious Disease (Notification) Act of 1889 was likely to lead to a still further increase in the number of these establishments.

In commenting upon the diseases calling for isolation, Dr. Thorne says: —

> So far, there is no evidence that aggregation of the infectious sick suffering from any of these diseases, except small-pox, such as is likely to be carried out by any ordinary sanitary authority, leads to infection of the

* Paper read at Congress of Charities, Correction and Philanthropy, at Chicago, June, 1893.

surrounding community, provided that the hospital be properly constructed and administered, and subject to a zone of some forty feet being provided between all buildings intended to receive infected persons or things and the boundary wall, or close fence around the site. Experience has shown that it is otherwise with small-pox, and it yet remains to be ascertained what are the circumstances under which cases of that disease can be aggregated for the purposes of sanitary authorities without risk to the community. Fortunately, owing to the protection afforded by vaccination, small-pox does not, as is commonly supposed, stand foremost among the infectious fevers calling for isolation in a hospital. As a rule, port sanitary authorities alone make provision for cholera.

Extent of Provision.—No exact rule can be laid down as to the requisite amount of provision for any given population. A general estimate has been made in England of one bed to each 1,000 inhabitants as sufficient for ordinary requirements. But the character of the population must largely determine this question. Upon this point Dr. Thorne says:—

In a locality where the population is well-to-do, and most houses are of a size and construction that offer reasonable facilities for the isolation of single attacks of the current infectious fevers, the amount of hospital accommodation needed for public health purposes will be less than in a manufacturing district, where disease cannot be treated in the houses in which it breaks out without very great if not certain risk of spread.

With this point in view, it is quite plain that the amount of hospital provision per 1,000 inhabitants in a residential community like those of Brookline or Newton would necessarily be less than it would be in manufacturing cities like Lowell, Lawrence, Fall River and Worcester.

Character of Accommodation Required.—Dr. Thorne has so distinctly presented the essential conditions relative to the necessary accommodations of an infectious disease hospital in his recent paper at the International Congress of Hygiene, that I take the liberty to quote them as applicable in most particulars to our own cities:—

Premising that all the conditions that are deemed essential in the provision of a healthy dwelling-house are to be regarded as equally desirable in the case of an infectious hospital, I would only here refer to such other points as involve considerations peculiar to such hospitals.

(*a*) *As regards site.*—It is, as a rule, undesirable to select any site which is less than some two acres in extent; and, even then, regard should

be had to the need for extension of hospital buildings, whether for temporary purposes or owing to increase of population. Where practicable, only single-story hospital pavilions should be contemplated; and having regard to their distribution on the site, and to the outdoor exercise of convalescents, twenty patients to the acre will generally be found to be the limit of aggregation of sick on area.

(*b*) *As regards buildings.* — The administrative building should be distinct from all others. Nurses, when off duty, will live and sleep in it; tradesmen will call there for orders and with supplies, and relatives will there make inquiries as to the progress of the sick. This building should always be so placed as to control all access from without to the ward pavilions and other hospital buildings. The laundry, ambulance shed, disinfecting apparatus and mortuary should also be in one or more buildings separate from the administrative building and the ward pavilions.

No sanitary district can be regarded as properly provided for unless it has immediately available sufficient accommodation for the isolation of two different infectious diseases in both sexes, and some means for the special isolation of one or two patients needing separate accommodation, as, for example, cases in which the nature of the disease is at first doubtful. These requirements are usually met by the provision of two pairs of wards or rooms having no aerial communication with each other, together with one or two special isolation rooms. In sparsely populated districts these requirements may be combined in one pavilion, the separate apartments of which open separately upon verandahs. Such a building is commonly styled an isolated pavilion.

Each ward pavilion should admit of cross ventilation by means of windows in the two opposite side walls; the closets and ward sinks, having themselves independent means of cross ventilation, should be entered from the wards by means of a cross-ventilated lobby; all angles, vertical and horizontal, should be rounded, to prevent deposit of dust, etc., and a nurse's duty room should be provided. Assuming that each ward will contain the ordinary proportion of acute and convalescent patients, and that it is adequately ventilated and warmed, a minimum of 2,000 cubic feet of air per head is generally found to suffice in order to maintain reasonable purity of air; but much depends on the allotment of this amount of air to the individual patient. No excess in the amount of total air provided — as, for example, in the case of lofty wards — can compensate for crowding patients on the floor level; and hence the beds should be so arranged as to ensure for each patient a floor-space of some 156 square feet. And since it is in the neighborhood of the patient's mouth and nostrils that it is above all important to maintain the purity of ward air, it is of all things necessary to allot to each bed a separate amount of wall space, not less than some twelve feet in length.

(*c*) *As to allotment of bed-space.* — The best position for the beds is that one bed should occupy each one wall-space between a pair of win-

dows, the head of the bed to be at least one foot away from the wall, so as to facilitate movement of air about the patient's head.

Medical advice is often sought as to the number of beds that should be placed in any one ward of an infectious hospital. In suggesting an answer to this question I cannot avoid the conclusion that the practice of treating sick persons under circumstances which admit of the air by which they are surrounded being charged more or less by the emanations of other sick persons is wrong in principle, and that from this point of view any aggregation of the sick in wards is undesirable. But other considerations must, in the case of a large proportion of the population, be regarded as outweighing this one; and all that can be properly contended for is that the limit of such aggregation shall be decided by considerations such as are involved in securing freedom from any recognizable risk, together with such efficiency in general administration and nursing as is consistent with a reasonable regard for economy.

The several infectious fevers doubtless differ in regard to the amount of nursing which the sick require; but taking them as a group, and assuming that the ordinary proportion of acute and convalescing cases at varying ages are brought together, it may be held that any one nurse can rarely be expected to take charge of more than twelve patients. The moment this number is exceeded the nursing staff has to be doubled, and directly a second nurse is required it would be better in the interests of the sick that those whom she nurses should be in a separate ward. Holding this in view, I believe it will generally be found desirable that infectious hospitals should be built in pavilions so contrived that in each there shall be two wards, one for males and the other for females, containing together not more than twelve beds, the two six-bedded wards to be separated by nurses' duty-room and an entrance lobby.

The diseases for which persons may properly be treated in infectious disease hospitals are mainly those which are specially contagious in their nature, and are liable to spread from the sick to the well in consequence of proximity to each other in the small and ill-ventilated tenements of large cities. It frequently happens also that travellers stopping at hotels or boarding-houses are attacked with some infectious disease, and the business of the establishment is seriously hindered and sometimes stopped altogether for a time by the presence even of a single case of such disease. I have had occasion several times in the past ten years to investigate instances in which these circumstances were prominent. Under ordinary rules such cases cannot be admitted to the general hospital, but may very properly be taken to an isolation hospital for treatment.

The diseases which should be treated in infectious disease hospitals are scarlet fever, diphtheria, small-pox, measles, typhus fever, cholera, typhoid fever, and to these it would be proper to add in the Southern States yellow fever, a disease from which the New England States are generally exempt.

Practically, the first five diseases mentioned in the foregoing list are those for which provision is usually made in isolation hospitals. In referring to English practice upon this point Dr. Thorne says: —

Next to small-pox, scarlet fever is the disease for the isolation of which most efforts have been made by sanitary authorities. The various forms of continued fever, and notably cases of enteric fever, have also in many districts been somewhat extensively isolated. Diphtheria and erysipelas have occasionally been dealt with in isolation hospitals, and at times efforts have been made to stay the spread of measles in the same way. There are, however, conditions which render attempts to deal with measles by means of isolation specially difficult. The stage at which the disease becomes infectious often precedes that in which it is recognized; the subjects of its attack are as a rule of exceptionally tender years, and a large proportion of cases never come under medical treatment at all. Notwithstanding its fatality, therefore, it can hardly be expected that hospital provision by sanitary authorities will be deemed as pressing in the case of measles as in some other infectious diseases.

Scarlet fever is the disease for which isolation is most constantly and most urgently needed. The mortality it occasions exceeds that of any other communicable fever prevalent in this country. It is highly infectious, and there are no effectual means apart from isolation by which its spread can be stayed. Small-pox, the one disease which, if vaccination were properly carried out, should least call for hospital provision, may perhaps be deemed to stand next in order as regards the measures for isolation. In some towns typhus has prior claims to small-pox in this respect, and in all districts some provision should be made for the other continued fevers.

The foregoing extract from Dr. Thorne's report applies with equal force to the case of our own cities and towns at the present time, with this exception, that we should give much greater prominence to diphtheria as a disease requiring hospital isolation. The very slight importance apparently attached to diphtheria in the English report of 1880 is undoubtedly accounted for by the fact that the contagious character of the disease was not then so thoroughly established as it is at the present time, a dozen years later. A peculiar characteristic of diphtheria appears to be the permanence of its infection, and the liability to retain its vitality in houses and apart-

ments for a considerable period of time. Hence the propriety of speedy removal of infected persons to a special hospital constructed with reference to efficient methods of disinfection, which are ill-adapted for use in old, crowded and ill-ventilated tenements, which, with walls and floors and ceilings having many cracks, crevices and crannies, give abundant opportunity to harbor the specific infectious material of diphtheria.

While the mode of transmission of the infection of typhoid fever differs essentially from that of some of the other infectious diseases already named, it is undoubtedly true that many cases occur by means of personal infection from one person to another, and while the alimentary tract is the part through which the specific poison is received, and often by means of the public or private water supply, the fact should not be overlooked that there may be other modes of transmission than through the medium of the water supply. While writing this paper I had occasion to investigate a local epidemic in a small town, having circumstances which may briefly be stated as follows: In January last, a man was attendant as a nurse and watcher upon a typhoid fever patient living about two miles distant from his own house. After the recovery of the patient he went home and was taken ill with typhoid fever himself, and after him, successively, three of his children, a grandchild, and finally his wife, the disease having in his household a continuous history of six months' duration. Careful examination was made of the surroundings of the house, the water supply, the disposal of refuse, etc., and it did not appear that the local conditions were at fault, but the probability lay in the direction of personal infection from the first case to the second, and so on through the family. Doubtless food and possibly milk may have been a means of transmission of infection; but if the first case could have been taken to a hospital and isolated during his illness and convalescence, it is probable that all the remaining members of the family would have escaped the disease.

This is only a single example of multitudes of such cases, which are constantly recurring and in which a system of well planned isolating hospitals would necessarily diminish very greatly the number of cases of illness as well as the mortality. The practical result of such a plan when properly administered, is to limit outbreaks of infectious disease to the first cases and thus to prevent the occurrence of epidemics.

Further points relative to construction.—Brick, stone or iron are undoubtedly better than wood, and this statement applies more decidedly to infectious disease hospitals than to those which are to be used for general purposes. Especially is this true of the interior finish of wards and other apartments used by the sick. It is advisable to finish the walls and ceilings with a hard or impermeable surface, which has no cracks or inaccessible ledges which may retain infection, and a floor of best asphalt or of some similar impermeable material, although possessing slight disadvantages, is so much superior to wood for the purpose of cleaning, as to be well worthy of adoption for such uses in wards which are to be devoted to the most infectious diseases.

In adapting dwelling houses in small districts to the uses of infectious disease hospitals special care should be taken to select houses in isolated positions. Such buildings should not be used for this purpose in large cities.

Such hospitals should be erected in a careful and considerate manner, with due regard to growth of population, and upon a well defined plan. Dr. Thorne's inquiry showed that—

> The suitability of the hospital buildings in various parts of the country was to a very great extent dependent upon the circumstances under which they were erected. If a hospital is hurriedly built under the influence of panic, it is often not ready for occupation until the immediate cause of its erection has passed by; it provides accommodation of a very indifferent sort; it fails, almost without exception, to meet the permanent requirements of the district even when in amount it turns out to be more than the district needs; and thus the object of the hospital as a part of the sanitary defences of the district is often attained in a very imperfect manner and at a needlessly large cost.

Possibility of spreading infection.—It has sometimes been urged that such hospitals might become centres of infection from which diseases would spread to the neighboring districts. Careful investigation upon this point, however, among the numerous hospitals of this sort in Great Britain showed that no danger need be feared from this source except in the case of small-pox. A thorough investigation made by Dr. Power, in 1882, and reported to the Local Government Board, showed that in the neighborhood of the Fulham small-pox hospital in London, small-pox had increased almost in a direct ratio to the nearness of the population to the hospital. This

increase was also independent of lines of human intercourse. In point of time there was also a very marked relation between the varying use of the hospital and the manifestations of excessive small-pox in the neighborhood.

Hence much greater care is necessary in selecting an isolated site in the case of hospitals intended for the reception of small-pox patients than is necessary in the case of those which are to be used for other infectious diseases.

The following condensed table and general conclusions are taken from Dr. Power's report: —

Admissions of Acute Small-pox to Fulham Hospital, and Incidence of Small-pox upon Houses in Several Divisions of the Special Area during Five Epidemic Periods.

Cases of Acute Small-pox Admitted.	In Epidemic Periods Since Opening of Hospital.	Incidence on every Hundred Houses within the Special Area and its Divisions.				
		On Total Special Area.	On Small Circle 0-¼ Mile.	On First Ring ¼-½ Mile.	On Second Ring ½-¾ Mile.	On Third Ring ¾-1 Mile.
327, . .	Mar., 1877-end of 1877,	1.10	3.47	1.37	1.27	.36
714, . .	Jan., 1878-Sept., 1878,	1.80	4.62	2.55	1.84	.67
679, . .	Sept., 1878-Oct., 1879,	1.68	4.40	2.68	1.49	.64
292, . .	Oct., 1879-Dec., 1880,	.58	1.85	1.06	.30	.28
515, . .	Dec., 1880-Apr., 1881,	1.21	3.00	1.54	1.25	.61
2,527, . .	Five periods, . .	6.37	17.35	9.20	6.16	2.57

Conclusions Relative to the Spread of Small-Pox in the Neighborhood of Hospitals.

1. There has been in each epidemic period an excessive incidence of small-pox in houses in the neighborhood of the hospital as compared with more distant houses in Chelsea, Fulham and Kensington.

2. The percentage of houses invaded in the neighborhood of the hospital has become gradually smaller as the distance of the houses from the hospital has increased.

This gradation has been very exact and very constant.

3. Houses upon the chief lines of human intercourse with the hospital have not suffered more than houses lying in other directions from the hospital.

4. In point of time, there has been a very marked relation between the varying use of the hospital and the manifestations of excessive small-pox in the neighborhood.

This relation has not shown itself while the use of the hospital has been for convalescents only.

5. The appearance of excessive small-pox in houses around the hospital has never been delayed until the hospital has become full, or nearly full. It has been always most remarkable at the time when admissions to the hospital were beginning to increase rapidly.

In the succeeding months of active operations, though the use of the hospital may have gone on increasing, the excess of small-pox upon the neighborhood has habitually become less marked.

6. On comparison of different epidemics an almost constant ratio is observed between the amount of the hospital operations and the degree of excess of small-pox in the neighborhood.

7. The machinery of the hospital administration, with inclusion of defects in that machinery, does not account for the peculiarity of small-pox incidence within the three parishes of Chelsea, Fulham and Kensington since the establishment of the hospital.

8. There must have been some condition or conditions operating to produce the observed distribution of small-pox around the hospital that have pertained to the hospital as such, and that have been in excess of the condition of small-pox extension as usually recognized.

9. During the present epidemic period, and most probably during former similar periods, there has arisen in the atmospheric circumstances of the time, peculiar facility for the dissemination in an undamaged state of any matter that may have been given off from the hospital.

Disinfecting Apparatus. — An isolating hospital can hardly be said to be complete in all its appliances without a well-equipped disinfecting apparatus. This may be used, not only for the purpose of disinfecting the infected material which must necessarily be found in every such hospital, but will also prove a powerful ally to the local board of health for the disinfection of the infected articles which are to be found wherever scarlet fever, diphtheria, typhoid fever and other infectious diseases exist. Such articles include clothing, bed linen, mattresses, and all the textile fabrics which are capable of disinfection and are too valuable to be destroyed. Such disinfecting stations exist in Berlin and in Paris as separate establishments, and are conducted in the most thorough manner, and in accordance with the most approved methods. There is no reason, however, why they may not be employed as adjuncts to isolating hospitals, where such hospitals exist. The Board of Health of Boston has during the past year established such a station at its new infectious hospital at Swett Street.

a portable shape, and are now made, both in this country and in Europe, at considerably less cost than the stationary establishments.

Let us for a moment consider a practical illustration of such a system as I have outlined: A father, mother and four small children, the latter aged two, four, six and nine years, occupy a tenement of two rooms, including a kitchen and sleeping room, each about twelve feet square and seven and a half or eight feet high. The kitchen is the cooking and living room of the family, and both are heated by the kitchen stove. The sleeping room is occupied at night by the whole family, and after allowing for the space taken by the furniture there are in this room about 175 cubic feet of air space only to each person, which is doubled by the open door into the kitchen. The sleeping room has but one window, which, in winter, is kept constantly closed, and there is no special means for ventilation. I am not here describing an unusual case, but, on the contrary, one which is of very common occurrence in any one of our large manufacturing cities.

One of these little children is taken ill with diphtheria in its severest form. There is no provision in the city for such cases, and the mother gives the child the best care which she can afford under the circumstances. The neighbors are afraid to take the other children to their homes. The next child is too young to attend school, and the law excludes the older children from school during the prevalence of illness in the family, thus making their exposure to infection more certain. After days of weary watching another child falls ill, and then perhaps the mother herself, worn with care and solicitude for her little ones, becomes a victim to the disease. Meanwhile the youngest has died, and is laid out for burial in a corner of the kitchen, the living room of the family.

Dr. Russell, the health officer of Glasgow, in commenting upon such cases, which, in a crowded city like Glasgow, were once of very frequent occurrence, says, when contrasting the condition of the rich and of the poor: —

Last of all, when *you* die, *you* still have one room to yourself, where in decency you may be washed and dressed and laid out for burial. If that one room were your house, what a ghastly intrusion you would be. The

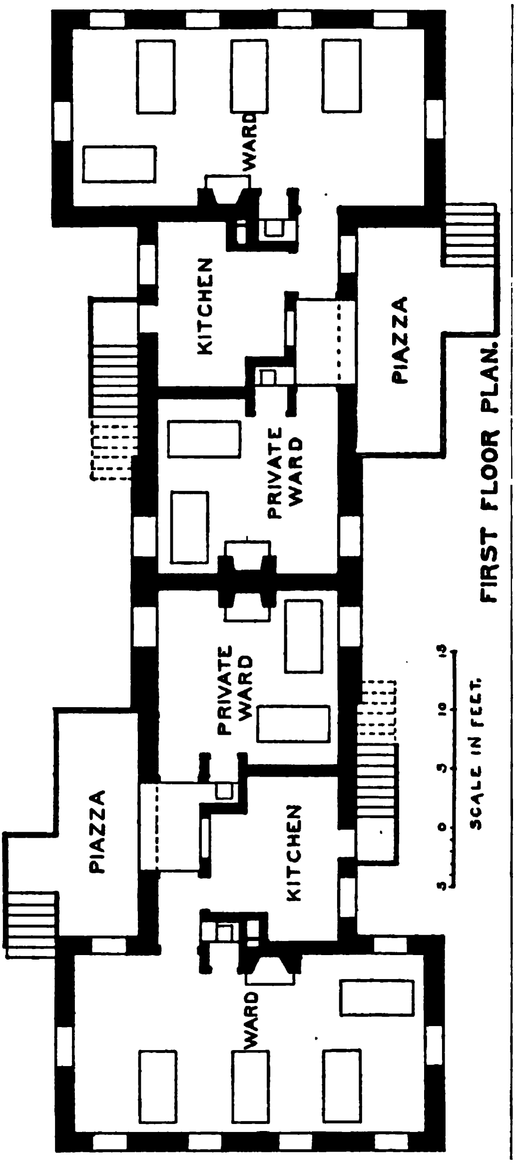
bed on which you lie is wanted for the accommodation of the living. The table at which your children ought to sit must bear your coffin, and they must keep your unwelcome company. Day and night you lie there until with difficulty those who carry you out thread their tortuous way along the dark lobby and down the narrow stair through a crowd of women and children. You are driven along the busy and unsympathetic streets, lumbering beneath the vehicle which conveys your scanty company to the distant and cheerless cemetery, where the acrid and deadly air of the city in which you lived will still blow over you and prevent even a blade of grass from growing over your grave.

Dr. Russell has here graphically described a death among the abodes of the poor, but when the death is from infectious disease, the conditions are still worse, since the added danger of infection to the remaining members of the family only doubles the distress of the household. Now for such conditions as I have described the infectious disease hospital provides a most excellent remedy, and while it may not prevent the occurrence of the first case in the family, it does provide for the taking of the infected person to a suitable place where he will not only receive far better care himself, but will not transmit the infection to his brothers, his sisters or to any other person.

In the hospital, too, in place of overcrowded and ill-ventilated bed chambers, there are large and well-ventilated wards; in place of foul air and darkness, there is fresh air and sunlight; in place of scanty food and food that is ill adapted to the wants of the sick there is food selected especially for the case in hand, and more than all this, there is good nursing and the best of care, and when the patient has recovered he is returned to his family, no longer a source of danger and of infection.

Of the few establishments of this character now in use in this State, one is at the State Primary School at Monson, where it was built about ten years ago for the purpose of receiving any cases of infectious disease which might arise in the school. It has proved exceedingly useful for the purpose of isolating such cases of scarlet fever, diphtheria and measles as have occurred in the school, and has undoubtedly prevented the outbreak and continuance of severe epidemics of these diseases, which are very liable to occur among children of such ages as are usually received at this school. When no means are provided for isolating sick children such epidemics often make sad havoc among them.

This hospital contains four wards capable of accommodating about twenty to thirty patients. It is entirely separated from the other buildings.



PLAN OF HOSPITAL FOR INFECTIOUS DISEASES AT CAMBRIDGE.

Still more recently an isolating hospital, very well planned and conveniently arranged, has been built at Cambridge, under the supervision of the trustees of the Cambridge Hospital.

A general plan of the main floor of this building is shown upon page 706. The arrangement of wards in this building is so planned as to admit of the treatment of two diseases, and also of the two sexes in each case, without any possible communication between the two halves of the hospital. Fourteen beds can conveniently be accommodated in the building. There are also two rooms for nurses in a second story not shown in the plan, separate from each other, each room being reached by a separate stairway.

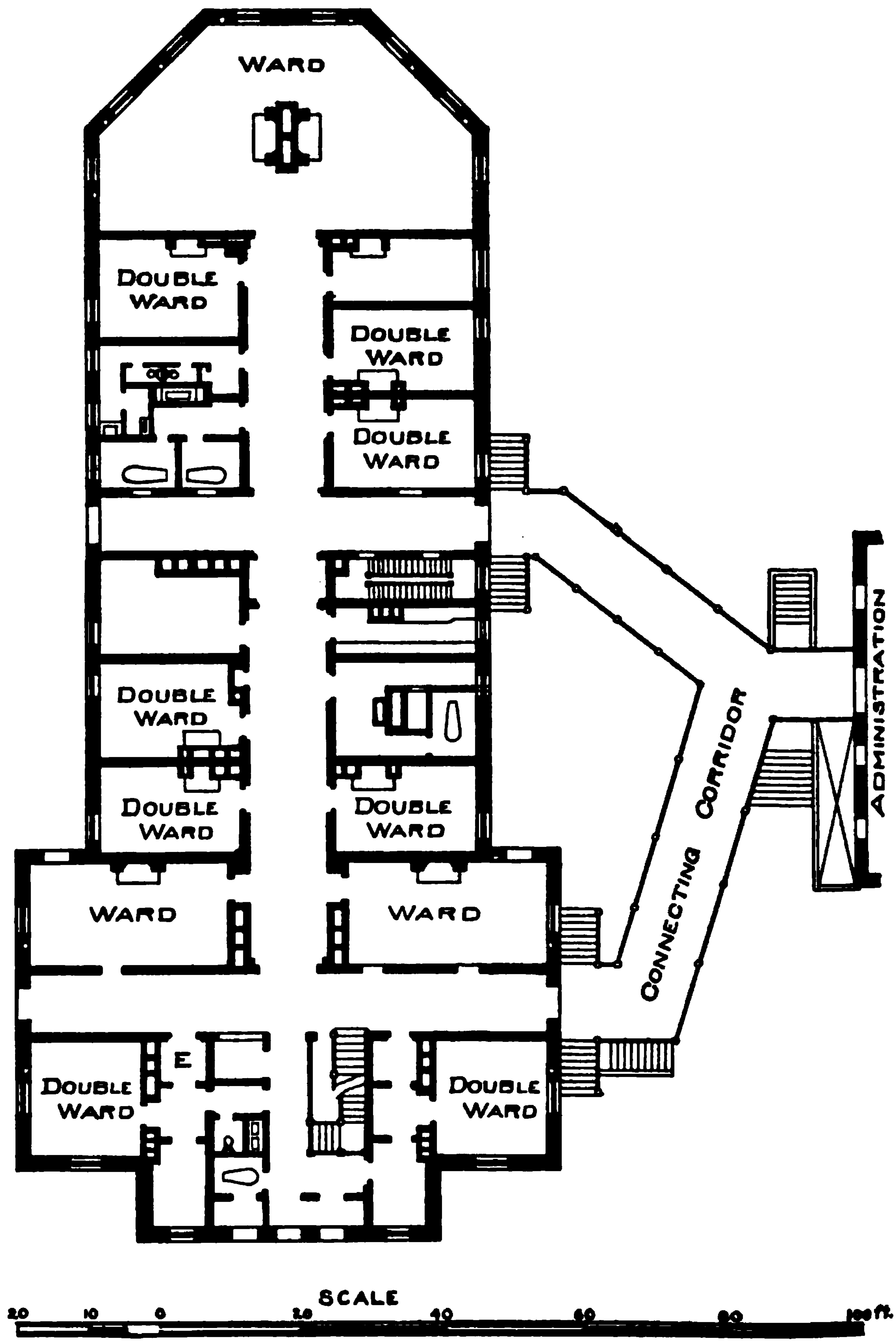
In describing the conditions essential to a well-contrived isolating hospital for a large city, Dr. Rowe makes the following valuable suggestions, some of which could hardly be carried out to the letter, except in large and wealthy communities: —

The wards should be of moderate size, not to exceed thirty beds. The number of buildings for each disease should be sufficient to allow one building to, so to speak, "lie fallow" for renovation and disinfection. This reserve is a large factor in reducing the mortality in an infectious disease hospital. This generous installation of site, buildings and appointments is not always practicable, either from the topography of a city, an available site or the financial condition of a municipality. Such establishments, however, do exist. The Belvidere Hospital for Infectious Diseases in Glasgow, Scotland, is a most notable example. It covers thirty-one acres of land, and has thirty-five buildings with accommodations for infection usually prevalent in a large city. No better argument for isolation hospitals can be adduced than a rehearsal of the experience of the health authorities of Glasgow, in changing the most unhealthy city of Great Britain, with the largest mortality rate, into a clean, healthful city, with a low death-rate.

Acting in conformity with the principles which Dr. Rowe has laid down in the paper from which I have here quoted, the trustees of the Boston City Hospital have now made provision for this purpose upon a lot of land near the city hospital in Boston. The group of seven buildings comprising this hospital, now nearly completed, consists of two two-story ward pavilions, connected by covered corridors with an administration building. The other buildings are a convenient lodge-house, a nurses' home, and a boiler-house, laundry, mortuary, etc. The cut on page 708 shows the first floor of one of the two ward-pavilions now approaching completion. As at present arranged, the wards are designed for 136 patients.

The wards at the City Hospital, now occupied for the reception of patients ill with diphtheria and scarlet-fever, were intended for only forty-two patients, but the urgent demands made upon the hospital

SOUTH PAVILION OF BOSTON CITY HOSPITAL FOR CONTAGIOUS DISEASES.



for receiving this class of cases has required them to be occupied by sixty patients much of the time.

"These difficulties," say the trustees in their report of the year 1892, "will soon be remedied by the completion of the Chester Park Hospital. For the purpose of carrying out this work $271,000 were placed at the disposal of the trustees for the construction of new buildings, $24,000 were set apart for the construction of a new ambulance stable, and contracts were made for the buildings, to cost $203,000."

In referring to this department of the work of the city hospital for the year 1892, Dr. Rowe says: —

The contagious service has been extremely active, a larger number of patients having been admitted than during any previous year. The total number of patients admitted with scarlet fever, diphtheria and other complications was 788. . . .

The diphtheria ward has seldom been crowded, although during several months it has been full. The character of the cases was severe, the marked characteristic being that a very large number were brought to the hospital in the last extremity. It follows that the mortality has been large. The scarlet fever ward has not only been full at all times, but during the winter months it has been crowded beyond a limit that was judicious. The hospital attempted to provide for all cases of scarlet fever that applied for relief. . . . Some applicants have been rejected because the wards were crowded to an extent detrimental to those under treatment. . . . When the new hospital for contagious diseases is completed it is expected its capacity will meet not only the present demands but also provide for any epidemics such as have hitherto existed in Boston, and also keep pace with the growth of the population.

The increasing favor with which hospital treatment for infectious diseases is regarded by the public is shown by the fact that in London the numbers admitted to the hospitals of the Metropolitan Asylum's Board increased from 2,197 in 1886 to 8,334 in 1890. One-third of all the infectious cases legally admissable were treated in those hospitals in 1890. In Brighton, England, in 1891, 70 per cent. of scarlet fever cases were so isolated.

"The whole drift of hospital provision is toward the prevention of epidemics by the isolation of first cases of infectious disease, the improvement of the treatment of the cases admitted upon that obtained at home being but part of the main object, but tending materially to diminish the mortality."

A very good illustration of a small and well-designed isolation hospital for a residential town of 20,000 inhabitants, or for a manu-

facturing town of a smaller population, may be found in the hospital at Ealing, England, which is represented in the accompanying illustrations. The grounds cover about two acres in a convenient location upon the outskirts of the village. The plan includes a hospital for about twelve or sixteen beds, with wards for two diseases, and opportunity to separate the sexes.

An administration house, porters' lodge, laundry, mortuary, ambulance shed and disinfecting apparatus are also provided. The grounds are surrounded by a brick wall about six feet in height. Space is also shown where tents may be erected upon a concrete floor in case of an unusual epidemic. The same space may also be used for future hospital extensions.

The cost of this establishment was about $30,000, including cost of land.

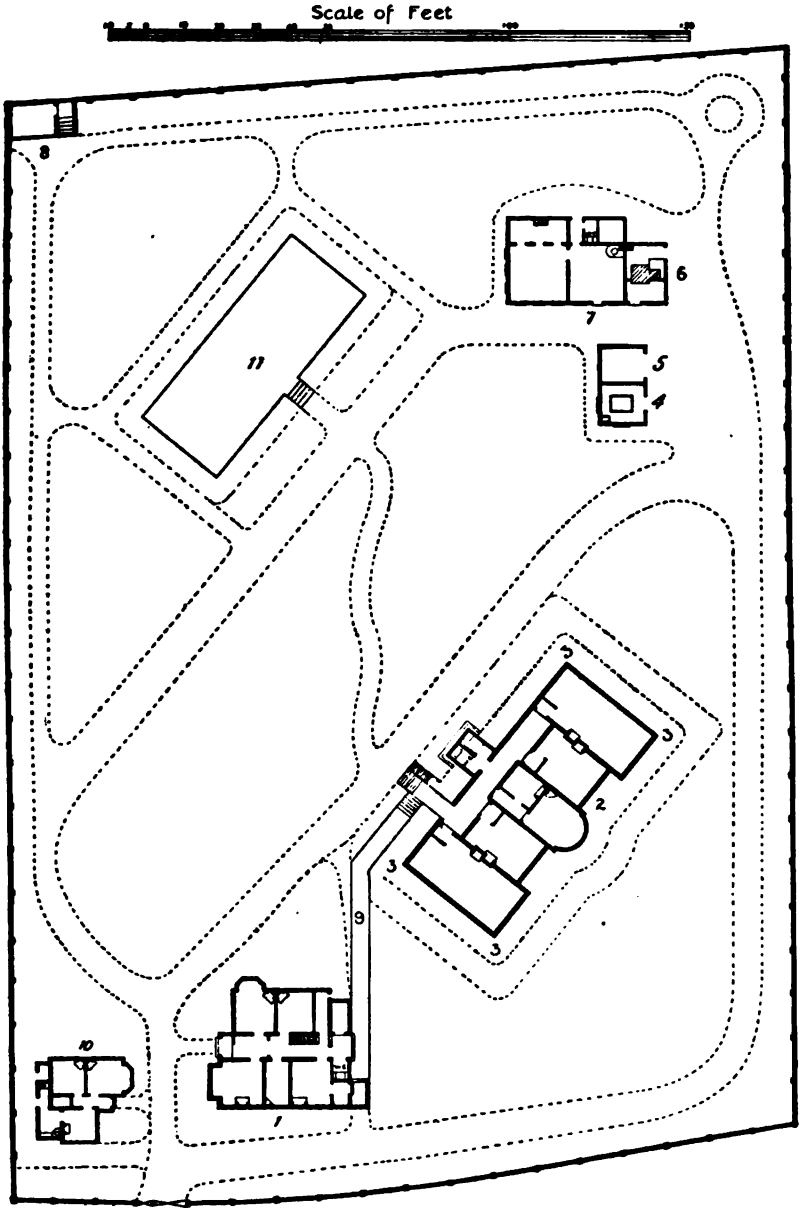
In the construction of buildings of this character the same general rules should be adopted as are applicable to hospitals in general. The trustees or committees appointed to take charge of construction should make themselves acquainted with everything requisite to secure the best buildings for hospital purposes which modern science and trained experience can produce. In illustration of the neglect of this precautionary measure Mr. H. C. Burdett, author of "Hospitals and Asylums of the World," cites the following instance: —

> This very autumn we had to inspect a new hospital, costing many thousands of pounds, where the committee and medical staff had taken infinite pains to secure a type of buildings which should be so good as to make their institution an example for others to follow. We found, however, that the buildings actually erected were a failure, and, what is more, a failure of the worst kind; that is to say, the faults were such as to astonish any one who had taken the trouble to make himself practically acquainted with modern progress in hospital construction. These faults were not due to the character of the site, or to any special circumstance, but arose entirely from ignorance, and what we venture to think is worse than ignorance, namely, an attempt on the part of the architect to adopt what he believed, no doubt, to be modern improvements without making himself acquainted with the purposes those improvements were intended to effect.

One of the first hospitals of this class was the London Fever Hospital, established about 1802, at Gray's Inn Road, and then known as a "house of recovery," where patients convalescing from infectious diseases could be taken while their homes were being cleansed or disinfected. It was afterward removed to better quarters, where

EALING ISOLATION HOSPITAL

EALING ISOLATION HOSPITAL



EXPLANATION.

1. Administration Block. 2. Hospital Block. 3. Area under the same, 6 feet headway. 4. Mortuary. 5. Ambulance. 6. Disinfecting Chamber. 7. Laundry. 8. Conservatory. 9. Covered Corridor. 10. Porter's Lodge. 11. Concrete floor for tents.

it served the purpose of isolating the infected sick, and thus protecting the healthy part of the population. (See plan of present London Fever Hospital, page 713.) The rows of dwellings upon each side of this hospital show its close relation to the neighboring population.

Since the scope of this paper will not admit of the details of hospital construction the reader may be referred with advantage to the excellent work of Mr. H. C. Burdett recently published, entitled "Hospitals and Asylums of the World."

In the fourth volume of this work are given brief descriptions of the following hospitals devoted to the care of persons suffering with infectious diseases: —

*London Fever Hospital.
Small-pox Hospital, Highgate (Lon.).

Hospitals of the Metropolitan Asylum's Board.

*Eastern (Homerton).
South Western (Stockwell).
*Northern (Winchmore Hill).
Northwestern (Hampstead).
*South Eastern (New Cross).
Western (Fulham).
North Eastern (Tottenham).
Hospital Ships (Long Reach).
*Ambulance Stations.

Provincial Infectious Hospitals.

Belvidere Hospital (Glasgow).
*Bradford Fever Hospital.
Bolton Borough Hospital.
*City Hospital for Infectious Diseases (Newcastle-upon-Tyne).
Delancey Hospital (Cheltenham).
Gateshead Hospital.
*Heathcote Hospital (Leamington).
Hull Corporation Sanatorium.
Infectious Hospital for the Joint Counties (Carmarthen).
Isolation Hospital (Huddersfield).
Isolation Hospital (Oldham).
Isolation Hospital (Hornsey).
Kendray Fever Hospital (Barnsley).
Ladywell Sanatorium (Salford).
Leeds House of Recovery.
Monsall Hospital at Manchester.
Netherfield Institution for Infectious Diseases (Liverpool).
*New City Hospital (South), Grafton Street (Liverpool).
Nottingham Borough Epidemic Hospital.
Port Sanitary Authority's Hospital (London).
*River Tyne Port Sanitary Authority's Hospital.
Sanitary Hospital at Bournemouth.
Sheffield Borough Hospital for Infectious Diseases.
Sittingbourne & Milton Joint Infectious Hospital.
Temporary Small-pox Hospital (Liverpool).

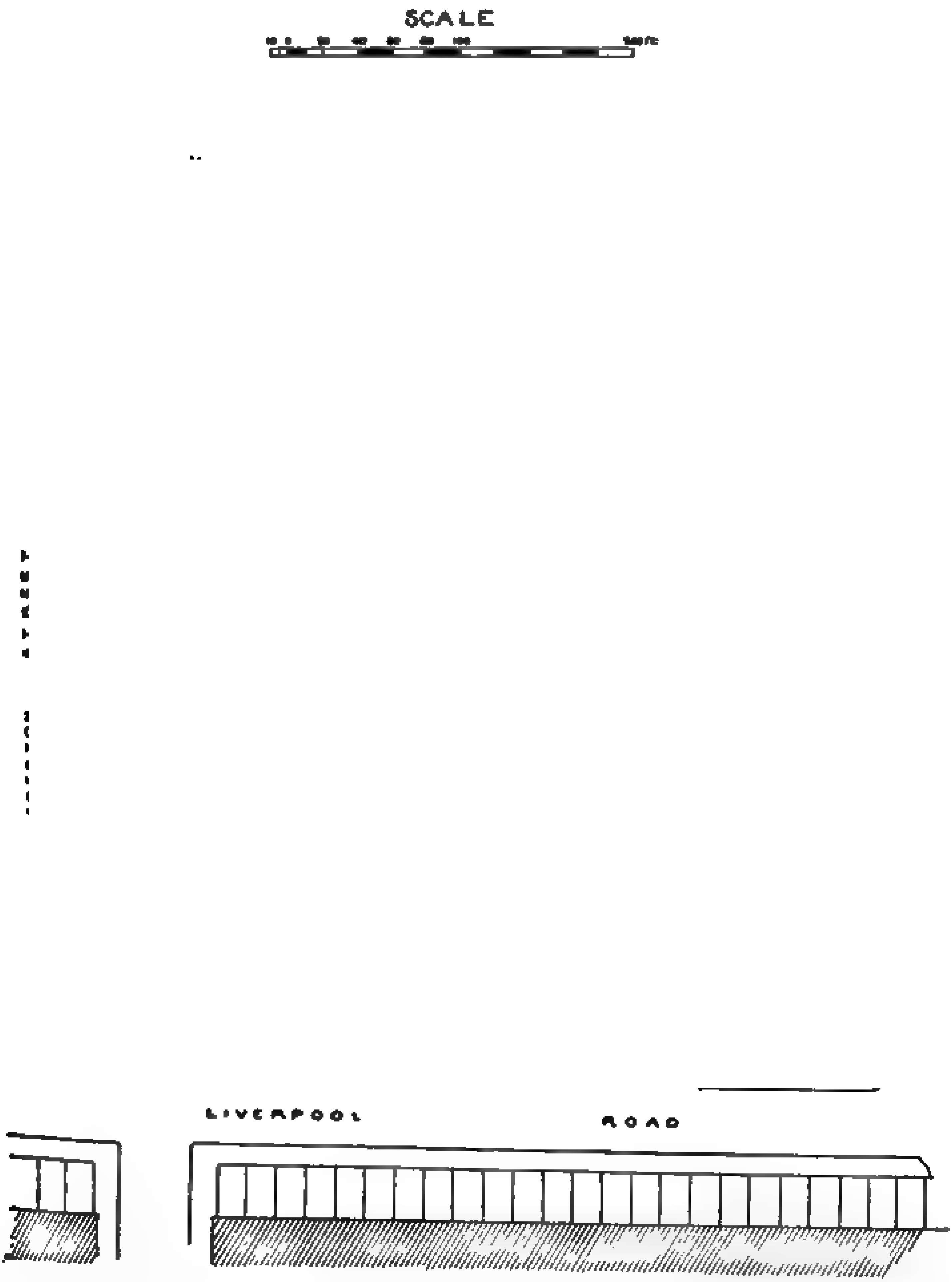
Continental Infectious Hospitals.

*Blegdams Hospital (Copenhagen).
*Ullevold's Hospital, Christiania Communal Epidemic Hospital (Sweden).
Oresunds Hospital.

School Sanatoria.

Rugby School Sanatorium.
King Edward VI.'s School, New Sanatorium (Sherborne, Dorset).
Blundell's School, New Sanatorium (Tiverton, Devon).

LONDON FEVER HOSPITAL LIVERPOOL ROAD. LONDON. N.



Probationary Wards.

In all infectious disease hospitals of considerable size it is desirable to establish probationary wards for the observation of doubtful cases. It is often very difficult to make a correct diagnosis at the outset of a case of infectious disease. Meanwhile great danger is incurred by the family or the household with whom the patient may be residing. It therefore is a matter of considerable importance to provide a place where the patient may be kept under such surveillance as will avoid danger to others, if the case proves to be infectious, and at the same time may avoid the infection of the patient if it so happens that his illness proves to be either non-infectious or a less dangerous disease.

School Sanatoria, or Isolating Wards.

A useful application of the system of infectious disease hospitals is found in its adaptation to the uses of large institutions of learning, or establishments of any sort in which young people are congregated, either for educational or for other purposes, away from their homes.

It is by no means a matter of uncommon occurrence for an outbreak of infectious diseases to take place among the inmates of institutions of this character. Such outbreaks invariably disturb the harmony of the college, school or other institution, and seriously interfere with the regular exercises. Many instances of such outbreaks are not only on record, but in some cases it has happened that the whole school or college population has been broken up and sent to their homes.

The existence of a single building, in which the first cases of infectious disease could be isolated and cared for until convalescence ensued, would in many instances have obviated much of this trouble.

Every large educational establishment should possess an isolating ward or hospital, which could in emergencies be used for this purpose.

While the infectious diseases of childhood are not so fatal nor so frequent among persons of school or college ages, their occurrence is yet sufficiently common among this class to require extreme care for their prevention, as the following figures will show.

The deaths from certain infectious diseases among persons between the ages of fifteen and thirty years in Massachusetts, during

the period of twenty-eight years ending with 1890, were as follows:—

From measles,	276
" scarlet fever,	763
" diphtheria,	1,430
" small-pox,	1,171

To the foregoing figures should be added the deaths from typhoid fever, a disease which finds its victims in the period fifteen to thirty years in the greatest numbers. The deaths from this disease at those ages for the same period in Massachusetts were 11,993.

Phthisis claims a much larger harvest from this age period than either of the foregoing diseases, the number of deaths being 57,197 for the same time and ages. In the case of phthisis, however, while its infectious character must be recognized, the peculiar nature of the disease unfits its victims for the continuance of prolonged study, and all such persons should be advised to discontinue their connection as soon as the nature of the disease is recognized.

Dr. Sykes concisely explains the differences between residential and non-residential schools with reference to the subject of isolation as follows:—

There is a strong contrast in the manner in which personal infection is spread in non-residential and residential schools. In non-residential schools children from various households meet at a centre, become infected, and returning, distribute the infection broadcast, closure being resorted to for the purpose of checking its spread. In residential schools, on the other hand, the infection is more or less confined to the limits of the school, and is only distributed beyond upon the disbandment of the pupils. Hence, it is interesting to note that opposite results may follow the similar process of closing a school, in the two cases, unless extreme precautions are taken.

Residential schools, like other residential institutions, protect themselves from admitting infected scholars from without by requiring certificates of freedom from infection, or from contact with infection, upon admission; and, when invaded, from the spread of infection within, by isolation in proper quarters. Non-residential schools, where the attendance is daily, do not admit of the application of measures of protection in this form, and are dependent upon school-teachers immediately excluding from attendance children suffering from infectious disease, or being members of an infected family or household. This exclusion can only be enforced by the teacher or manager being informed by the parents or by the sanitary authority of

sory notification is therefore a valuable protection to schools. If exclusion fails, and infection reaches a school, not directly but indirectly, by the commingling of infected with healthy children beyond the precincts of the school, it points to the absence of proper seclusion of the infected children at home or in hospital, and it is only when seclusion, as well as exclusion, fail to prevent an epidemic in a school that dissolution or closure of the school is justifiable. Defects of internal condition, structure or site liable to lead to such a result are naturally also included in such justification.

The memorandum* issued in December, 1890, by the chief medical officer of the Local Government Board explains in a very full and lucid manner the measures necessary to be taken in this direction for the protection of "public elementary schools" by sanitary authorities.

SUMMARY.

The advantages of the separate hospital for infectious diseases may be summed up briefly, as follows: —

1. They allow the complete isolation of the sick in cases where the sick cannot be effectively separated at their homes.

2. The work of the wage-earner, the ordinary duties of the household and the school attendance of children can go on as usual without interruption.

3. Infection is thus kept by itself in a place where it can be intelligently treated and destroyed. Otherwise, in tenement-houses and crowded dwellings, and among those who are ignorant of its nature and its proper management and control, it may spread and cause infinite harm.

4. Cities requiring such hospitals should not wait for the hurried impetus derived from panic, but should construct carefully and thoroughly, and with due regard to their own special needs. Such hospitals, like fire departments, when completed should be always ready for immediate use. They should be accessible and under wise and intelligent management.

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* Quoted in full in twenty-third annual report of State Board of Health, 1891, page xvi.

APPENDIX.

Practice of Different Countries.

In the following pages are grouped some of the essential data relative to the progress of different countries in this particular direction for preventing the spread of infectious diseases.

For a portion of this information the writer is indebted to Dr. Palmberg's recent work entitled "Public Health in its Applications in Different European Countries."

England.

Memoranda of the Local Government Board of England.

Regulations as to Hospitals (Memorandum on Hospital Accommodation). —Means for separating the sick from the healthy should always be provided. When two contagious diseases break out at the same time, they should each be separately isolated.

In towns, and for several villages of smaller size, there should be provided at least two special wards with four beds in each, in order that the sick may be isolated from the commencement. Such a very small infirmary would be very valuable for arresting the progress of an epidemic.

Fig. 1 represents a very simple type of hospital, having one ward for each sex, with the necessary annexa. This plan accompanies the memorandum of the Local Government Board.

Fig. 2 represents two sections of the same building, the one to the left having simple walls and serving for summer rooms; the one to the right having double walls is a permanent structure. At the base of the external walls are openings for the admission of fresh air, seen on the front of the elevation (Fig. 1). In the roof are other openings for the escape of foul air, but chimneys or special tubes are the best for this purpose.

In rural districts without a hospital, a trustworthy married couple without children may be charged with the isolation and care of cases of infectious disease. In the event of a more serious epidemic, several lodgings may be hired for the sick, or they may be isolated in temporarily erected tents or barracks.

Fever hospitals in urban districts ought to have one bed for every 1,000 inhabitants. In manufacturing towns with a very dense population, this proportion ought to be even greater; while in wealthy and less dense towns, with houses of a good class, one bed for every 2,000 inhabitants may suffice.

Permanent fever hospitals are built on the system of separate pavilions. There must be at least four wards for patients, as well as a pavilion for administration.

Sick wards can be arranged in pavilions connected in pairs, as shown in Fig. 3, which is taken from the memorandum of the Local Government

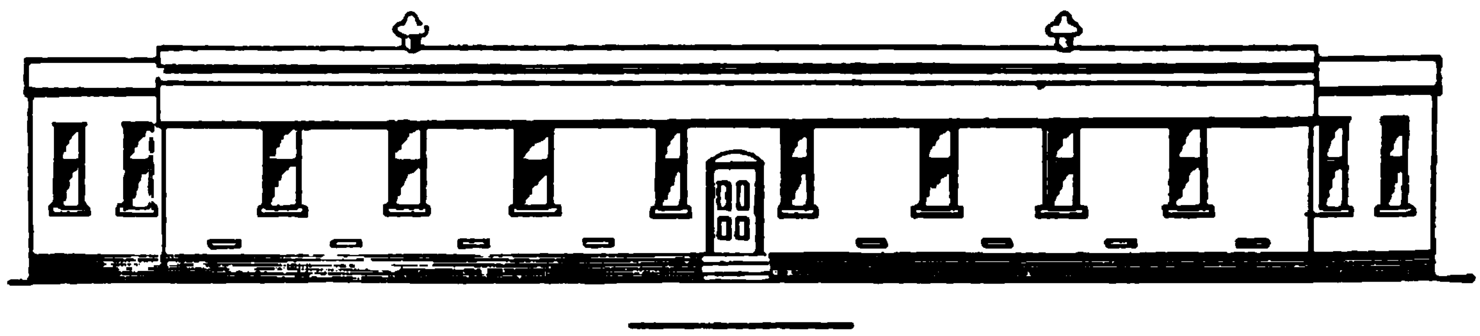
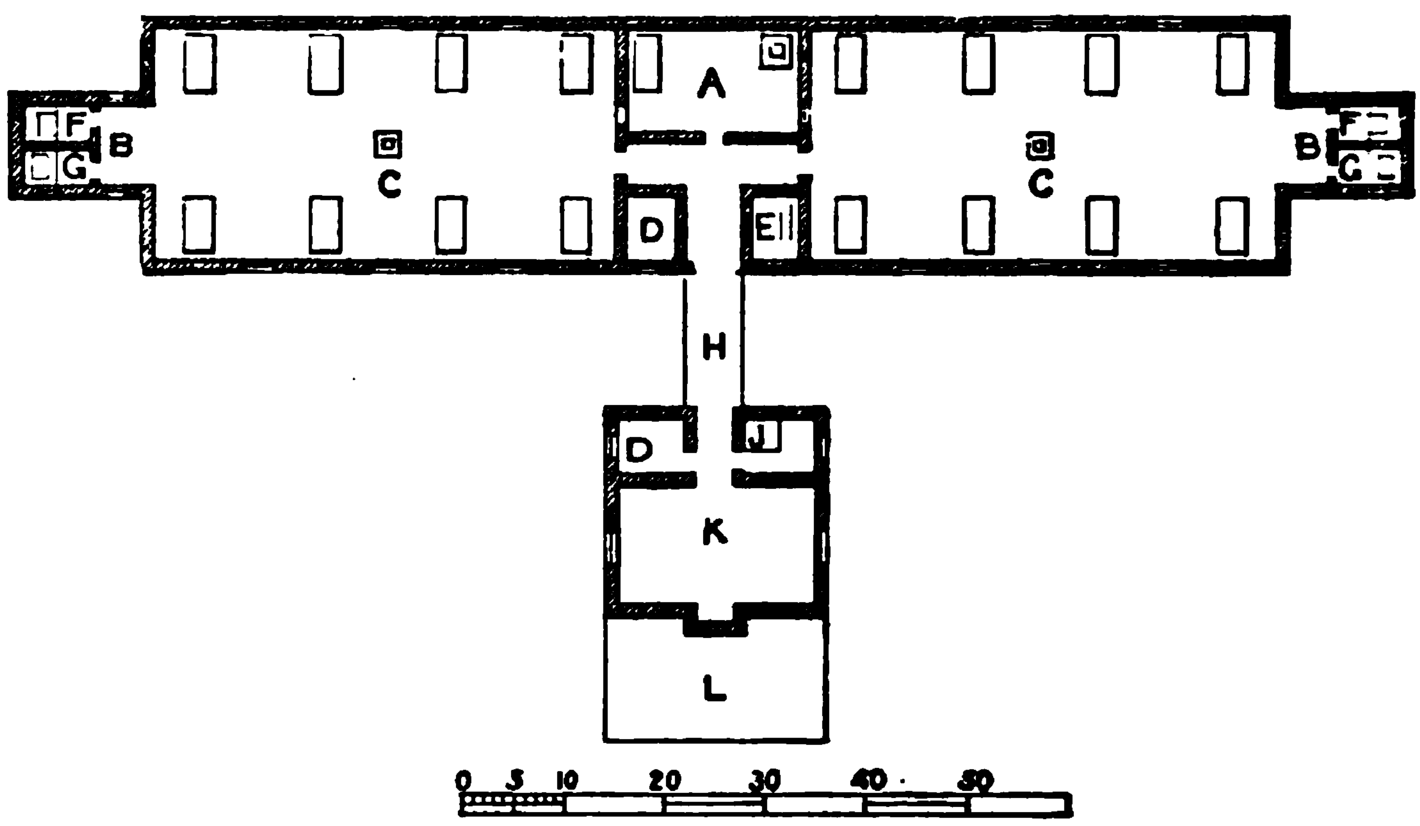


Fig. 1.-Plan and Elevation of a Small Hospital.



A. Small separate apartment. B. Passage connecting the two wards. C. Stove. D. Store-room. E. Bath-room. F. Water-closets. G. Lavatories. H. Covered way. J. Coal-house. K. Kitchen. L. Space for additional buildings if required.

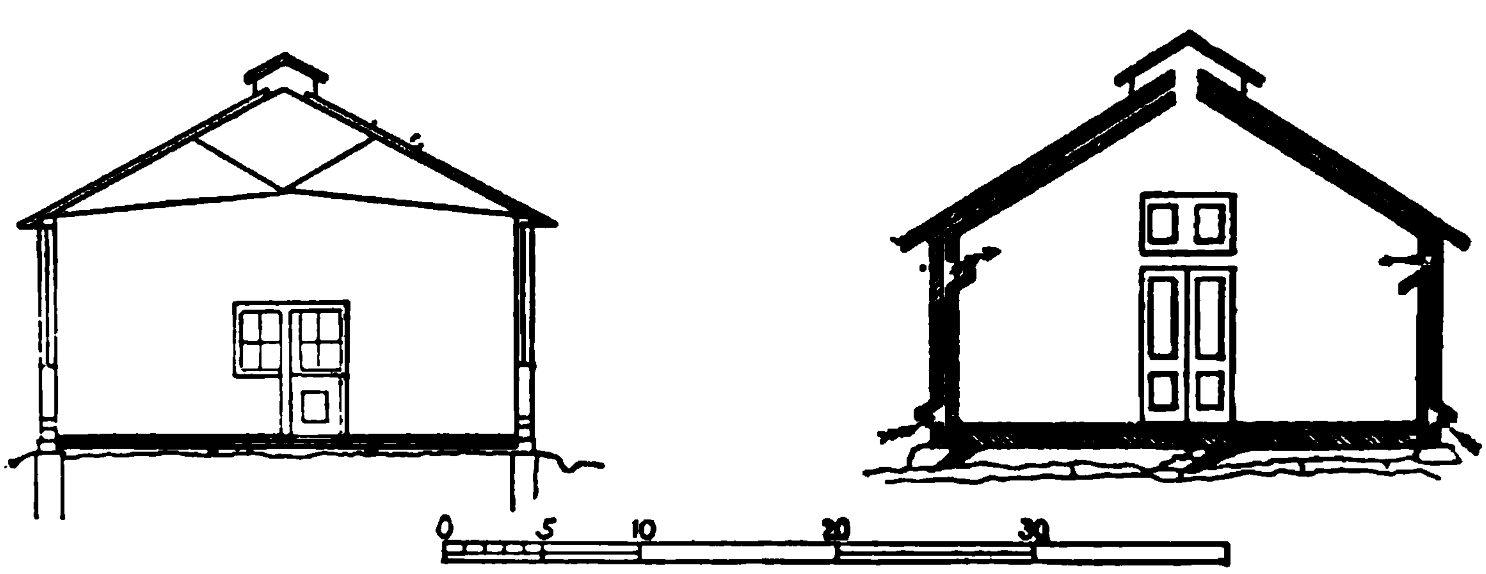


Fig. 2.—Vertical Sections through same Hospital.

Board. The dotted lines in this figure show how, as the population increases, the permanent hospital can be enlarged.

The minimum distance between the pavilions should be thirty feet.

Fig. 4 shows another arrangement of sick wards which is preferable when sufficient ground is available.

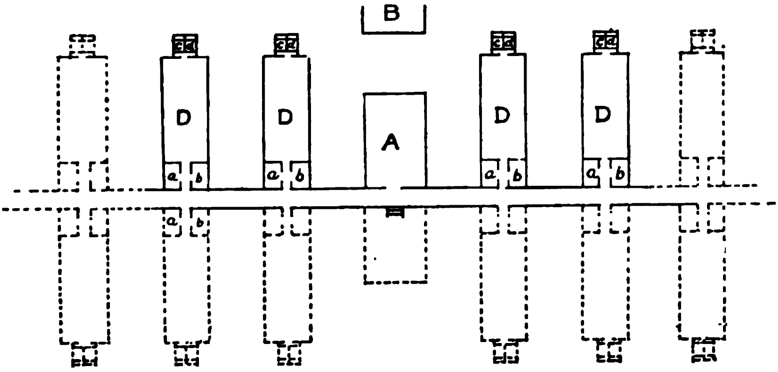


Fig. 3 — Permanent Hospital in Pavilions.,

The sick wards may also be placed on different stories of the same pavilion.

Two of them, one for each sex, are reserved for persons suffering from the same infectious disease.

All the wards should be kept separate, and independently warmed and ventilated. To facilitate the work of the staff a corridor connects all the

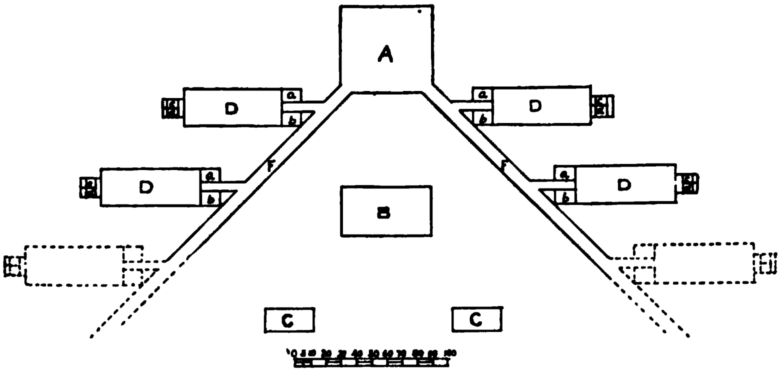


Fig. 4.—Another Arrangement of Permanent Hospitals in Pavilions.

A. Administrative building (kitchen, store, sleeping accommodation for nurses and servants). B. Laundry, etc. C, C. Disinfecting chamber and mortuary. E. Corridor. D Wards for patients with ten beds in each, lavatory and bath-room (a, b) next the corridor; closets and sinks (c, d) at other end, separated from ward by a cross-ventilated corridor.

pavilions. The latter should be so placed that the air can circulate freely between them. The space between the pavilions should be at least one and a half times as great as the height of each pavilion; and if a pavilion is intended for small-pox, the distance should be still greater. It is preferable to place small-pox in an entirely separate building as remote as possible from all other buildings.

In wards for infectious diseases there should be openings for admission of fresh air between each bed, a little above the floor, so that pure air bathes the patient's bed. They should be furnished with a grooved fastening, so that the admission of air can be graduated. The openings for extraction of foul air should be near the ceiling, and as remote as possible from those admitting fresh air. They should, unless entering into the chimney-breast, be carried vertically to the roof and be provided with an aspirating cowl.

Memorandum of Ambulances.

For the conveyance of patients who are sick with infectious disease, special carriages or ambulances are necessary. The following points have to be attended to in the provision and use of such carriages: —

1. If the ambulance be intended only for journeys of not more than a mile, it may be made so as to be carried between two people, or it may be on wheels and to be drawn by hand. If the distance be above a mile, the ambulance should be drawn by a horse. Every ambulance on wheels should have easy carriage springs.

2. In the construction of an ambulance, special regard should be had to the fact that after each use, it has to be cleansed and disinfected. The entire interior, and the bed-frame and bed, should be of materials that can be washed.

3. The ambulance should be such that the patient can lie at full length in it; and the bed-frame and bed should be movable, so that the patient can be arranged upon the bed before being taken out of his house.

4. With an ambulance there should always be a person specially in charge of the patient; and a horse ambulance should have a seat for such person inside the carriage.

5. After every use of an ambulance for infectious disease, it should be cleansed and disinfected to the satisfaction of a medical officer.

6. Both in very populous districts, and in districts which are of very wide area, it may often happen that more than one ambulance will be wanted at one time; and in any district, if more than one infectious disease is prevailing, there will be an evident sanitary advantage in having more than one ambulance for use.

Rules for Hospitals for Infectious Diseases.

1. The medical officer is the responsible superintendent of the establishment. It is his duty to visit the hospital even at times when there are no patients, to ensure that the matron and nurse are at their post, and that everything is ready for the reception of patients.

2. The matron and head nurse ought to maintain the greatest cleanliness and to see that the beds are well aired, conveniently arranged, and always ready to receive patients. They ought also to keep the inventory of everything belonging to the hospital. They are forbidden to absent themselves together without express authority. They must carry out the orders of the doctor and be responsible for the conduct of the staff and the nurses.

3. The matron (or steward, if there is one, as in large hospitals) must be prepared monthly to present the books of accounts to the sanitary authority.

Instructions for Nurses, Patients and Visitors.

1. Every applicant for admission to a hospital should have a medical certificate of the disease from which he is suffering.

2. A patient can be attended by a doctor of his own choice other than the medical officer of the hospital at his own cost.

3. No person is admitted to the hospital without the permission of the medical officer.

4. No patient is permitted to leave the hospital until discharged by the medical officer.

5. The patient's clothes must be disinfected before being given up to him at his discharge.

6. Officers and servants of the hospital are not allowed to leave the hospital without authority of the medical officer; and they must first change their clothes.

The following table contains some of the most essential data relative to several of the hospitals embraced in Dr. Thorne's report. Values are expressed approximately, in United States equivalents, instead of English money.

Statistics Presenting Cost of Construction of Isolation Hospitals and other Items.

District.	Estimated Population.	Number of Beds.	Present Bed-rate per 1,000 of the Population.	Floor Space per Bed. Square Feet.	Ward Capacity per Bed. Cubic Feet.	Cost of Hospital, excluding Site.	Cost of Bed, excluding Cost of Site.	Remarks.
Berkhampstead (rural), .	11,000	8	0.7	144	2,000	$10,525	$1,315	The addition of a second pavilion will increase the number of beds to 16, the administrative building sufficing for the requirements of increased accommodation, and the cost per bed will then amount to less than $875.
Cheltenham (urban), . .	44,000	35	0.7	144*	2,300*	54,160	1,690	When the total of 56 beds has been provided the cost per bed will be reduced to $1,090.
Darlington (urban), . .	35,000	44	1.3	144-175	2,000	49,300	1,095	Ward extensions are provided for.
Folkestone (urban), . .	18,700	14	0.7	140	2,000	13,635	974	Two other pavilions to be erected containing together 22 beds. There is also a separate small-pox hospital with 4 beds, raising the present bed-rate to 0.9 per 1,000 population.
Lewes (combined districts),	11,200	8	1.1	144	2,000	9,620	1,200	Two thousand three hundred dollars were spent in excavations, etc., in connection with the site. There is no disinfecting apparatus.
Middlesbrough (urban), .	56,000	32	0.6	122-180	1,620-2,100	33,250	1,037	This hospital, though constructed for 32 beds, actually contains 48. The cost per bed is calculated on the number it should properly contain. Enlargement of several existing wards is provided for.
Sheffield (urban), . .	285,000	64	0.2	138	1,810	96,350	1,505	Cost of preparing site was heavy; $8,750 was thus expended.
Solihull (rural) . . .	20,000	12	0.6	144-156	2,000-2,184	14,085	1,174	- - - -
Tonbridge (urban), . .	10,000	12	1.2	140	2,000	6,290	526	Walls of pavilions less substantial than desirable; some use made of materials already in hand.
Warrington (urban), .	42,000	28	0.7	144-175	2,058-2,529	31,920	1,140	Two more pavilions to be erected. Over $975 spent in providing an inefficient ambulance and disinfecting stove.
Weymouth (port), . .	-	26	-	144-169	2,014-2,028	25,000	985	No enclosure wall deemed necessary. No disinfector yet provided.

* Average.

Glasgow.

The following description is quoted from the official report of the trustees of the Glasgow Fever Hospital: —

"The grounds possess great natural beauty, rising gently as you approach the Clyde, where they are broken by three small glens, once the beds and sloping banks of three streams. The whole estate is well wooded, especially along the avenue and western boundary, where the rooks have recently established themselves in the tops of the old beeches. The convalescents are allowed to wander at will over the many beautiful walks, and in the summer it is one of the most pleasant sights to see the children rolling about on the grassy slopes of the glens, and the seats, placed here and there, occupied by groups of people who for the first time in the lives of many are tasting of the sweets of Nature. At the rear of the fever hospital several acres are laid out as a flower garden, with a greenhouse, from which the wards are supplied with potted plants. Flower plots are distributed here and there between the pavilions and in other open spaces. At a distance of some four miles southward, the wooded heights of the Cathkin Hills close in the horizon."

"The whole buildings, except that occupied by the medical and nursing staff and matron, are built of brick. The wards are distributed in pairs, in thirteen totally isolated pavilions, all running north and south. They are sixty feet apart laterally, and are placed in rows of two, three, four and five, in succession from the bank overlooking the Clyde towards London Road. They have thus, to one standing in their midst, the appearance of a large, uniformly laid-out village. Each pavilion is only one story in height, with a well-ventilated basement beneath, so that the level of the ward is reached by a flight of steps. The two rows of four pavilions are separated by a range of buildings running east and west, the centre of which contains the kitchen, one story in height, and, like the pavilions, open to the roof. At either end there is another story, the eastern accommodating various stores and the dispensary; the western, the under servants' rooms. At London Road there is a main lodge controlling to the west the entrance to the small-pox hospital, and to the east, the approach to the fever hospital. At the south end of this approach is the fever lodge and enquiry rooms for patients' friends, with the Dorcas Society's stores in an attic story, and running north along the avenue, the morgue, with room for funeral parties, with entrance from the road so that hearses, etc., do not come within the hospital enclosure. Just inside this gate is the washing-house and laundry, with the suite of steam boilers to the south, a cremator for soiled beds, and the central coal depot. The boilers are three in number, double-flued, and in size seven feet six inches by twenty-six feet four inches. Further south are a smithy, carpenters' shop and fire-engine station. Southwestward, some forty yards, are the stables, ambulance

shed, etc. Still westward is a large three-story stone block, erected on the site of the old mansion house, containing eighty-four single bed-rooms for nurses, with recreation rooms on each flat. These occupy the lateral wings, while the centre is reserved for the matron and medical staff. In front of this building there is a spacious lawn, with tennis court, bounded southwards towards the Clyde by a sloping bank planted with trees."

"There are three hundred beds on the scale of 2,000 cubic feet for adults; but as a large proportion of the patients are children, for whom 1,200 feet is sufficient, a much larger number of patients can be accommodated. The dimensions of every pavilion and ward are exactly the same; but as they were erected at different times, sundry little but important differences exist. The two southern pavilions were built last, and the description of one will suffice. It has a basement eight feet from ground to floor level. The outside length, from end to end, is one hundred and sixty-eight feet; the outside breadth, twenty-six feet; the height, from ground level to ridge of roof, thirty-two feet. There are two wards, each divided into a convalescent and acute ward. A flight of steps on both sides gives access to a vestibule, from which, on one hand, are the entrances to these subdivisions, while, on the opposite side, is the pantry, opening directly off the passage, and a lobby, to the left of which are the bath-room and water-closet, and to the right a steep-room for soiled linen, these last being farthest from the wards. All these appurtenances are therefore completely isolated in a projecting annex. The entrance and annex of each ward are on opposite sides of the pavilion. On the side opposite to the entrance of the acute ward is a nurse's duty room, where there is a 'poison press' and a napery press, with chairs and a table. The front projects into the ward with sloping roof and glass sides, giving a full view of the ward. The internal dimensions are as follows: acute ward, length, 56 feet 3 inches; convalescent ward, length, 24 feet. In both the breadth is 22 feet; the height to the wall head, 14 feet 6 inches; to the roof tree, 23 feet 9 inches. The floorage of the acute ward is 1,237 square feet; of the convalescent, 528 square feet. The total cubic contents of the acute ward are 23,500 cubic feet; of the convalescent ward, 10,000. The number of adult beds is eleven for the acute and four for the convalescent ward; but in the case of children twenty cribs are allowed."

"All the flooring of the wards is of Dantzic oak, waxed. The vestibule and annex are laid with tiles. The walls are coated with Keene's cement. Some wards are oil-painted and varnished, but the more recent are treated with light blue or green distemper, which can frequently be renewed. All the woodwork is varnished. Care is taken to avoid flat surfaces giving lodgment for dust. The principal rafters are, therefore, of light T iron, and the tiles of thin rod iron."

"The heating is by hot water circulating in pipes which are led round the walls above the floor. This is derived from two hot-water tanks heated

by steam, and placed beneath the entrance hall of each ward, to which access is obtained from the outside by a stair leading to the basement. There are also open fires at either end of each ward. Pavilions with numerous windows and open to the roof are very difficult to warm sufficiently during winter. Experience at Parliamentary Road soon showed that it would be necessary to check radiation by the large glass area, and accordingly the device of double glazing each pane with an interval of three-quarters of an inch of air space was adopted. The wards at Belvidere are kept at 55° to 60° in the coldest weather. There are heating coils in the vestibule and bathroom."

"Fresh air is admitted by direct openings beneath the windows, which are numerous, so that it passes over the heating pipes. These openings are controlled by an arrangement which admits of gradation, and cannot be interfered with except by the nurse. There are skylights on opposite sides of the slope of the roof, Boyle's ventilators fixed on the ridge, and ventilating shafts alongside the chimneys, with openings controlled by movable louvres and the apex of the roof."

"The principles kept in view in furnishing are simplicity, smooth surfaces and facility of removing and cleaning. The bedsteads are wrought iron, the tables and chairs hardwood, varnished. In the children's wards, iron cribs are provided, and pigmy forms and tables suited to their size. All cupboards, presses, etc., are movable on iron rollers, like American trunks. The mattresses are stuffed with straw, the pillows with chaff. They are renewed for every new patient and whenever soiled. Wood wool was recently tried as a substitute for straw, but was found speedily to break down, and, on account of the consequent expense and larger quantity and more frequent renewal, was not adopted."

"The nurses are graded in three classes — probationers, nurses and head nurses. After a year's probation, during which she attends lectures on fever nursing given by the assistant physicians, the probationer is submitted to a written and *viva voce* examination. If she passes satisfactorily, she gets a 'Certificate of Proficiency in Fever Nursing,' first, second or third class, signed by the physician superintendent, and becomes a nurse. The wage of a probationer is £18, and advances gradually to £30, all getting two uniform suits per annum for ward use alone. To work a purely pavilion hospital such as Belvidere, all its parts distributed over a large area, and to maintain the large extent of flower garden and pleasure ground attached, requires a large staff. The distribution of coals is done by an open lorry, on which all the coal-boxes are placed and driven round the wards. The food is distributed by a covered van, divided into compartments, each of which holds the allowance for a ward. The ashes are collected daily from portable circular-covered ashbins countersunk in the ground adjacent to each ward, an arrangement which combines convenience and perfect sightliness and inoffensiveness. The whole institution is under

ness of the hospital by a house steward, and in the medical charge by two permanent medical assistants. These are supplemented, as occasion requires, by extra assistants. In fact, there are seldom less than three assistants, and usually in the autumn and winter there are four or five. These appointments are in great request among the best students of the Glasgow school. They are only given to qualified men, and by preference to such as have been house surgeons in either of our infirmaries. They remain from one to two years. The present physician superintendent, Dr. J. W. Allan, was appointed in August, 1875, and has contributed much by his urbanity, good management and rich experience to win and to retain the confidence which Belvidere undoubtedly possesses both with the profession and the public."

"In calculating the cost of treatment, the expenditure on the small-pox hospital is always thrown in with that on the fever hospital. There having been only rare and isolated cases of small-pox for some years, 120 beds have been constantly used for scarlet fever, and only one pavilion, barricaded off with the whole administrative buildings, for small-pox. A small staff is maintained there. The last financial year for which the accounts are made up (June 1, 1886, to May 31, 1887) may be taken as an illustration of the expenditure, number and nature of cases treated, etc. There was not a single case of small-pox treated, but £558 were expended in the small-pox hospital; £15,945 in the fever hospital; 2,790 cases were treated, including 1,270 cases of scarlet fever, 504 of measles, 204 of enteric fever, 176 of whooping-cough, 87 of typhus, 134 of erysipelas, diphtheria, chicken-pox and puerperal fever, the balance being made up of nursing mothers and cases of mistaken diagnosis. The average residence over all was 43.3 days (which is high, owing to the regulation residence being eight weeks for scarlet fever); the average daily number of patients, 332; the average cost of treatment per patient, £5 18s. This does not include interest on capital expended in building and furnishing hospitals, but does include ground, annual and all current expenditure in maintaining the whole estate and working the hospitals. Taking one year with another, the average mortality is: for typhus, 13 per cent.; enteric fever, 12 per cent.; scarlet fever, 12 per cent.; measles, 5 per cent.; whooping-cough, 12 per cent.; and over all cases, 10 per cent."

"In the northeast corner of Belvidere estate, the central washing and disinfecting establishment for the city is situated, occupying an area of 2,500 square yards. In those times when the treatment of infectious diseases was left to the Royal Infirmary, whatever disinfection was carried out at the houses of the patients was also performed by the directors. In their annual report for 1824 they refer to this fact. The first washing-house established by the authorities was a small place with a few tubs in a close off the High Street. This was opened in 1864. When Belvidere was

acquired, half of the existing fever hospital washing-house was reserved for this purpose. This soon proved inadequate, and the present separate establishment was finished, in 1883, at a cost of £8,400. It is essentially a washing-house, fitted up with the best mechanical appliances, to which the articles to be treated are driven by a service of vans. There is a Lyons disinfector, in which mattresses, clothing, etc., which cannot be washed, are disinfected, a cremator for burning straw, chaff, wool, flock and other articles, 'whose end is to be burned,' and a carpet-beating machine. It has just been resolved to spend £800 in improving the arrangements, and especially in adding appliances, devised by the sanitary inspector, for treating everything which is ultimately to be washed with a solution of bichloride of mercury, which, it is expected, will make the articles innocuous before passing them on to the washers. On an average, 1,000 articles per day are treated in one way or another."

"The hospitals, the washing-house, and the sanitary office in the city are all in telephonic connection."

Germany.

The following regulations pertain to the organization of hospitals for infectious diseases in Germany.

A. The building must be isolated and situated in an open space, if possible, away from inhabited quarters, but at such a distance that the patients may be taken to it without difficulty or distress.

B. There must be no communication between the hospital and its surroundings, and, where necessary, complete isolation must be established.

C. The beds must be separated by at least seventy-five to ninety centimeters and each patient allowed fourteen cubic meters of space. (These requirements would hardly meet the demands of modern hospital hygiene.) Convalescents are placed by themselves. Hospitals must be provided with spare wards so that the occupied wards may be vacated from time to time and carefully purified.

D. The air of the hospital must be kept fresh and pure. The furniture must be kept perfectly clean, as well as the rooms.

E. The clothing of the patients must be separately stored and carefully disinfected before it is returned to them.

F. Convalescents must be isolated till they leave the hospital.

Berlin.

Hospitals for Isolation.

At Berlin the preventive measures against infectious diseases are organized according to the regulations in force throughout the Empire.

A large hospital for isolation has been built by the corporation, composed of twenty-four detached pavilions of one story, with an additional

building for emergencies. A space is reserved for the construction of six additional pavilions.

This hospital (das städtische Krankenhaus Moabit) is situated in a space nearly open on all sides on the Moabit quarter, near to the public park, and small Thiergarten. The ground has the form of an elongated rectangle. Pavilions are built on the long sides facing east and west. The distance between each is seventeen meters, and the two sides are separated by sixty-four metres. The intermediate space is occupied by lawns, groups of trees and shrubs.

The buildings cover a surface of 10,000 square meters, of which 6,432 are occupied by buildings; the grounds, mortuaries, etc., take up the remainder.

Each pavilion contains a ward 28.25 meters in length, 6.90 meters in width, and 3.14 meters in height. Each contains thirty beds — too many in a hospital for infectious diseases, as that allows only twenty-seven cubic meters for each patient. The ward is lighted by windows in the side walls, one being placed between every two beds.

The materials employed in the construction are blocks of wood intercalated with bricks. The inside walls are lined with boards painted in oil a bright color. The floor is formed of a bed of concrete.

There are no ceilings. The roof is composed of a double layer of boards, painted in oil inside and covered outside with millboard saturated with asphalt.

A skylight runs along the middle of the roof with lateral apertures, which may be opened and shut from within.

A vestibule at one end, traversed by the entrance corridors, comprises on its right side servants' rooms and the dispensary, and on the left, the bath-room, linen-room and water-closets. All these rooms have boarded floors.

The heating is effected by means of steam-pipes connected with a boiler, which also serves for the kitchen and laundry. A large steam-pipe runs in a subterranean trench in front of the pavilions, sending a branch to each, which is subdivided into several pipes for warming the rooms and heating water for the bath-room. Three steam-pipes, two to the north and one to the south, run above the floor at a height of 0.30 meters; they are provided with taps for the regulation of the temperature. The condensed water returns to the boiler by a pipe.

Ventilation is very simply managed. Fresh air is introduced by means of fourteen openings, each eighteen centimeters wide, made in the walls of each ward at the same height as the steam-pipes, which warm the air as it enters. The impure air escapes by the lateral apertures above.

The rooms, etc., are lighted with gas; the lamps are hung below the skylight, and assist in the ventilation.

The pavilion for special isolation attached to the hospital is similarly constructed and measures 15.67 meters in length by 8 meters in width, and

3.64 meters in height. It contains three rooms separated from one another, each having three beds. A covered veranda, 2.30 meters in height, runs along the front. Large doors at each end set up a current of fresh air.

Eleven casements are placed in front of the veranda near the roof, which are removed during the summer.

A water-closet is provided for each room, placed in a vestibule, and abutting on an outside wall, being perfectly ventilated and separated from the ward by an ante-chamber.

Each of the wards has a roof of a pyramidal form, at the top of which is a ventilating-pipe surmounted with a Wolpert aspirator. The floors are made of brick covered with Metlach mosaic.

Heating is effected by steam introduced into hot-air stoves, placed in the middle of the floor, and so constructed that the heat can be regulated. The stoves are surrounded with an iron jacket.

Fresh air is supplied to the apparatus by a trench in masonry under the floor, and is warmed in passing between the stove and the jacket. The impure air escapes partly by the ventilating pipe in the roof, partly by other pipes adjoining a small tower in the ceiling of the veranda, in which are placed water-cisterns for the baths.

The rooms may also be heated by steam-pipes.

At one end of the veranda is a small enclosed room, into which linen for the wash is thrown through a trap-door; it is taken away by a door communicating with the open air.

There is a place for disinfection in the establishment through which the linen is passed.

When no epidemic prevails, part of the hospital is given up to ordinary patients. It is, however, considered preferable to nurse the latter in the städtische allgemeine Krankenhaus Friedrichshain, which is a splendid hospital built in pavilions, four of which have one story and six two stories. There are also two pavilions for isolation with two stories and another of one story exclusively reserved for diphtheritic patients.

In the department for isolation each adult is allowed a space of fifty-seven to sixty cubic meters, and each child thirty-one to forty-two cubic meters.

The pavilion for diphtheria is warmed by steam, but the general method is a combination of heating by means of hot-water apparatus connected with the ventilation. Each ward has also chimneys open in the summer and autumn.

In order to assist ventilation the smoke-pipes pass through the ventilating shaft.

The removal of persons suffering from infectious diseases is entrusted to contractors charged with the maintenance of the necessary carriages, the use of public carriages being forbidden to such patients in virtue of an official order of the 7th of February, 1887.

Paris.

No satisfactory system for the treatment of persons sick with infectious diseases in hospitals specially designed for this purpose has yet been effected, but a commission was appointed to investigate the subject, and reported in June, 1887, to the municipal council. Thus far, persons attacked with infectious diseases have been received into all hospitals, except small-pox patients, who were only admitted to the hospitals of Saint Louis and Saint Antoine, which had isolated buildings for their accommodation. In the other hospitals the infected are also isolated, but experience has proved that the measures taken for that purpose have not been effectual, and it too often happens that infection is propagated within these establishments. Statistics also show that there has been an increase in the deaths from infectious diseases in Paris, while they have sensibly diminished in other cities where isolation is better organized.

There is a station at the Hotel Dieu in connection with the transport of infectious cases, in which are kept two horses, two carriages and a driver. When any person ill with a contagious disease requires to be taken to the hospital, notice is sent to the nearest police station, whence it is transmitted to the Prefecture, who then sends orders to the Hotel Dieu. The disinfection of carriages is prescribed by the regulations, but this duty is left to the driver, without supervision.

The plan already mentioned provides for two ambulance stations, one on the right bank of the Seine, near the Hospital of St. Antoine, and the other on the left bank, near the Hospital for Sick Children. Each of these stations is to have twelve carriages for removal of the sick. Two will be reserved for small-pox, two each for measles, diphtheria, scarlet fever and typhoid fever, and the last two will be reserved for other diseases — whooping-cough, erysipelas, etc. The carriages used for one disease are never to be used for another. Each coach-house must be divided into six compartments in order to prevent mistakes. The stable will be arranged for six horses, though it will not be necessary to keep more than two in them under ordinary circumstances.

A certain number of nurses will be assigned to each ambulance to accompany the patients. They will live in the adjoining hospital and give their services in turn.

The staff of the station will consist of a chief officer, two coachmen, one of whom must be married, and a servant, who may be the wife of the latter. All these persons will live on the premises, and the staff, as well as the nurses, will be boarded there. The estimated cost of construction of each station is about $14,000, and that of each carriage about $500. Each is to be provided with a seat for the nurse, near the pillow of the patient, and a drawer for clothes and linen. After each journey the carriage is to be thoroughly washed. The stations are to be connected by telephone with the Relief Board and the Prefecture.

Hospitals.

As a part of this general plan, four hospitals are to be erected near the gates at the entrance of the city. Two will be devoted to small-pox, and one each to diphtheria and to measles. The first are designed for seventy beds in each. The plan provides for reserving a plat of ground near by, so that in case of need supplementary pavilions may be constructed with accommodations for more than eighty more patients. This ground is to be levelled, covered with asphalt and drained, so that temporary buildings can be put up in a few days. If further accommodation is required, it is proposed to build a hospital for convalescents at Creteil, southwest of Paris, on ground belonging to the Relief Board.

A hospital for diphtheria also forms a part of the plan, to be erected near Bicêtre, at the south end of the city.

The following figures show the special need for arresting the progress of diphtheria and measles in Paris : —

Mean Death-rate from Diphtheria per 10,000 Inhabitants, Paris.

From 1865 to 1869,	4.32
" 1870 to 1874,	4.72
" 1875 to 1879,	8.88
" 1880 to 1884,	9.26
" 1885 to 1887,	7.68

Mean Death-rate from Measles per 10,000 Inhabitants, Paris.

From 1865 to 1869,	3.18
" 1870 to 1874,	3.35
" 1875 to 1879,	3.72
" 1880 to 1884,	4.90
" 1885 to 1889,	5.71

Scarlet fever does not appear to have found a congenial soil in Paris, the average mortality per 10,000 from this cause being but 0.9 as compared with 1.7 in London, 1.2 in Edinburgh and 3.2 in Berlin. Measures for its restriction there do not therefore appear to be so imperative as in the case of the infectious diseases already named.

With the view of diminishing the spread of whooping-cough it has also been proposed to found a great isolating establishment, including a school and a hospital.

The public disinfecting stations form a part of the general plan for the prevention of the spread of infectious diseases. Those of Paris and Berlin are most thoroughly equipped, and managed in the most effective and systematic manner. Their description, however, does not come within the scope of the present paper.

Later information upon the subject of isolation of contagious diseases in Paris may be found in a paper contributed to the International Congress of Charities, Correction and Philanthropy at Chicago in June, 1893, by Drs. Herbert and Hogg of Paris.*

The following summary is presented in that paper of the facilities which are afforded in Paris for the isolation and treatment of hospital patients suffering with contagious diseases. The hospitals providing such facilities are six in number: —

The *Aubervilliers Hospital* possesses separate buildings for small-pox, measles, scarlet fever, erysipelas, diphtheria and doubtful cases; in all, 184 beds.

The *Hospital Trousseau.* Isolation wards are established for children with diphtheria, measles and scarlet fever (181 beds).

Hospital "des Enfants Malades" (Enfants Jésus), which is a hospital for children, receives diphtheria and scarlet fever patients (52 beds).

In addition to these the following hospitals are provided with isolation rooms: *Lariboisière*, 7 beds; *La Pitié*, 5 beds; *La Charité*, 3 beds.

All of these taken together furnish a total of 332 beds.

SWEDEN.

In Sweden, local public health administration is in charge of a Commission of Hygiene, in the towns (Helsovardsnämnd); and in rural districts the Communal Council is entrusted with sanitary functions. These have been organized by laws of 1874 and 1885.

During the prevalence of an epidemic of infectious disease the Commission must attend to the following regulations: —

1. The immediate removal of the patient to a special hospital, a place isolated for the purpose, unless the transport should endanger the life of the patient. He may remain in his own dwelling if he can be nursed according to the regulations prescribed by the Commission.

2. The immediate disinfection of the house, clothing, bedding, etc., of the patients who have died, recovered or been sent to the hospital.

3. Patients are not to be removed in public carriages; stretchers, sedan chairs, etc., are disinfected after use.

4. Clothing of the patients, and anything belonging to the hospital which has been lent or sold, are to be disinfected.

Persons suffering with epidemic or infectious diseases cannot refuse to be removed to the special hospital unless life would be endangered, or they can be nursed in a place properly isolated, at their own expense.

When two infectious diseases prevail at the same time, two special hospitals should be established, or, at least, a properly isolated portion must be set apart for the treatment of one class of patients.

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* Hospitals, Dispensaries and Nursing. Papers, Discussions, etc., at Congress of Charities, Correction and Philanthropy, June, 1893. New York, 1894.

Stockholm.

Population about 225,000. In Stockholm the plan presented in 1884, by Dr. Linroth, Chief Medical Officer, for the purpose of organizing the treatment of infectious diseases in the city includes —

1. A hospital placed at one end of the city, organized in a pavilion system, and comprising —

A building for small-pox, with	20 beds.
A building for typhus fever, with	20 "
A building for scarlet fever, with	35 "
A building for diphtheria, with	28 "
A building for measles, with	35 "

A building with, at least, ten small observation rooms, each having one bed.

A building for the staff, containing also rooms for the medical officers of the establishment.

Buildings for offices, such as kitchen, laundry, place for disinfection and the burning of straw, stables, coach-houses and ice-houses.

A place should be reserved on the same ground for two temporary hospitals, the plans and drawings for which must be quite ready so that they can be erected without delay in case of need.

2. A branch establishment at the other end of the city, organized after the same system, and comprising —

A building for scarlet fever, with	30 beds.
A building for measles, with	25 beds.

A building for the staff, and two rooms for special cases.

A building for the offices of the establishment.

3. An establishment situated in the group of islands on this side of Vaxholm, intended to receive infectious patients who have arrived by sea, and comprising a pavilion with fifteen beds; a place for disinfection; a building for the staff and officers.

4. A place for disinfection within the city for the healthy members of families exposed to infection, and for suspected clothing. The number of beds available should be one hundred and forty-eight in the large hospital, fifty-seven in the branch establishment and fifteen in the island hospital, in all two hundred and twenty beds.

Dr. Linroth is of opinion that typhoid fever may safely be treated in the other hospitals of the city as in previous years.

The construction of a new isolation hospital on the above plan was only begun in 1890. The hospital comprises five pavilions, comprising altogether one hundred and sixty-two beds, a building with eight observation

rooms, a building for the administration and for the doctor, one for cooking, a laundry, mortuary, etc.

Before this time the old hospitals were utilized, temporary buildings being erected for special requirements.

These are constructed of double boards. The interstices of the walls, floor and ceiling are filled up with charcoal.

A barrack on this model was erected in ten days in the park of Bellevue near Brunsviken, when an epidemic of small-pox was threatened. The expense amounted to about £700.

A permanent erection has been constructed on the ground of the hospital Saint Maria to serve as a place for isolation. Its total length is 32.30 meters and the width 7.50 meters. Its height is 15.50 meters between the ground and the ridge. The front, which looks towards the west, is flanked by a fore-court eight meters in length by 5.5 meters in width. The sides are made of boards 7.5 centimeters thick, wainscoted and lined with mill-board outside and inside. The roof is of mill-board covered with asphalt.

The building contains two wards, with thirteen beds in each. The space between the wards is occupied by a room for the nurse, a linen-room, and a small kitchen for making drinks. Behind the vestibule adjoining the wards, which can be divided into parts, is a fore-court in which are placed the latrines and the bath-room. The floors of the wards are made of asphalt, laid on a bed of cement, which is placed on the ground, covered with a bed of broken stones and gravel. The other rooms have also asphalt floors, excepting the nurses' room.

The walls and ceilings are painted in oil throughout the building, in order that they may be easily cleaned. Each bed in the wards has 7.20 square meters of floor space and 30 cubic meters of cubic space. The windows are made in the side wall of the ward, and look east and west, there being eleven in each ward. The windows are two meters in height by one in breadth, their total surface being about one-fourth of the floor. The establishment possesses a gas and water service. There are two baths made of copper in the bath-room. The latrines are arranged on the system of movable tanks used in the city, but in such a way that the urine flows away separately by a subterranean pipe. In the closets there are also cisterns in zinc for the soiled linen, a current of water continuously passing through them from top to bottom, and discharging into the sewer. The speed of the current is regulated at pleasure.

In this way all risk from the handling of dry linen worn by the infectious patients is avoided. The linen is not taken from the water and wrung until the moment when it is to be sent to the wash. The cisterns have lids locked with a key.

Heating and ventilation are effected by means of a kind of stove with an iron casing lined with fire-proof bricks. The casing does not come higher

than the middle of the stove, and is 6 centimeters from it. The total height of the apparatus is 3.60 meters, the exterior diameter, 0.60 meter; the heated surface, 7 square meters.

The fresh air, entering by a pipe sixty centimeters by thirty, arrives at the bottom of the stove and is heated in passing between the stove and the casing. The ventilating-pipe is provided with a sliding valve.

The stoves are arranged for slow combustion, fed at long intervals during the day, and kept locked.

The impure air escapes by pipes heated in the chimney, each discharge pipe having an opening near the floor for ventilation in winter and one under the ceiling for summer; the valves of these openings are enclosed that they may be out of reach of the patients.

The upper sash of two opposite windows in each ward is provided with hinges below, so as to open within, and has an iron plate on each side.

All the air-pipes are arranged so as to be easily cleaned.

During the summer more thorough ventilation may be secured by a water ventilator on Trentler and Schwartz's systems, fixed in the roof, above the centre of the building. This ventilator is put into communication with the wards and the outer air in such a way that air may be admitted or excluded at pleasure by opening or shutting valves.

The cost of this barrack is about £1,440.

The city keeps a special carriage for the removal of infectious patients. It is lined inside with varnished wood, which can be easily cleaned after each journey.

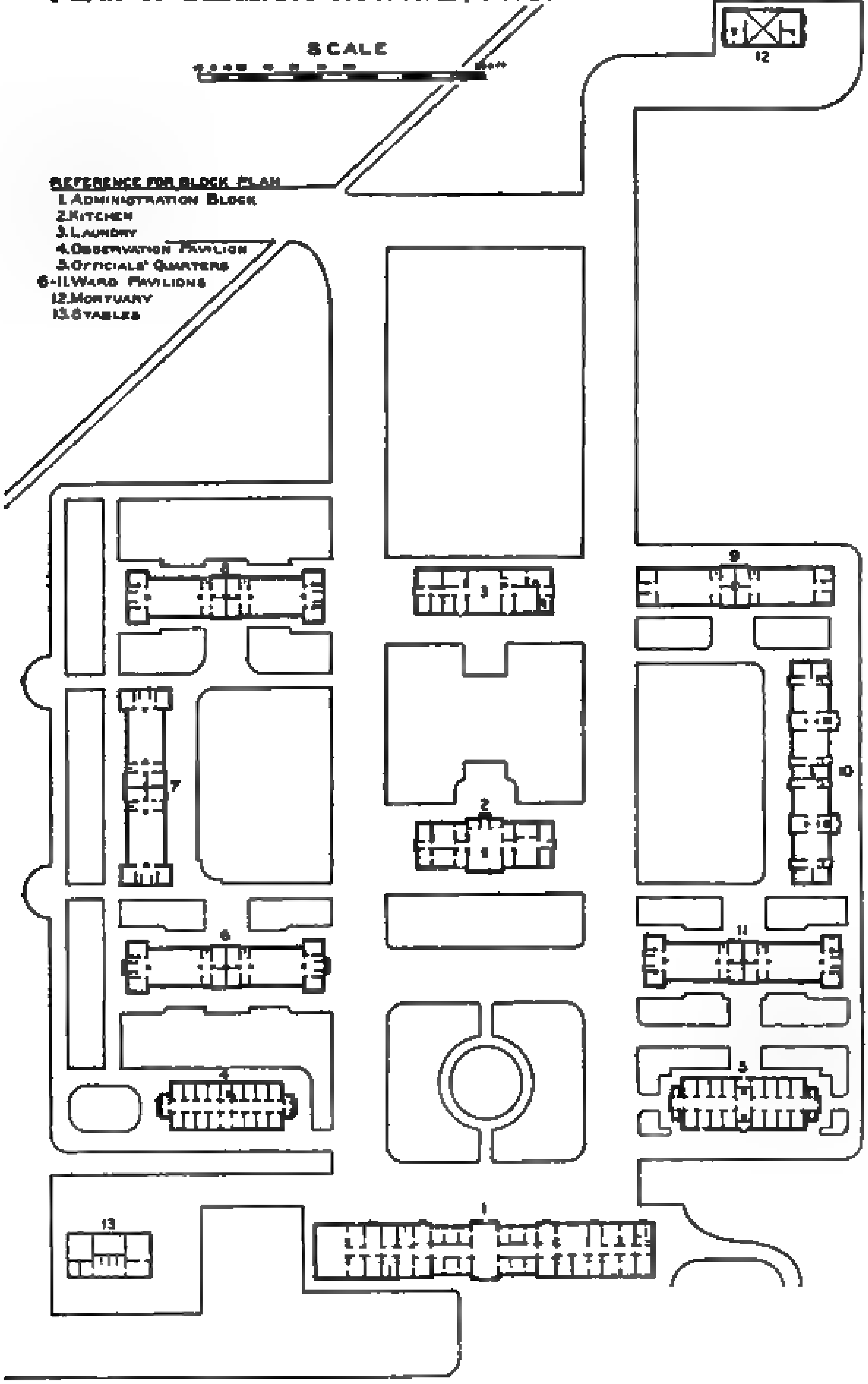
Denmark.

Copenhagen.

The wards of Blegdams Hospital are fitted up with special care for the treatment of patients with infectious diseases. There are eight one-storied pavilions, two for twelve patients each, six for twenty-six each, and a two-storied pavilion for seventy-eight patients; besides, there are some movable marquees (felt tents of Docker's patent), with accommodations for fifty patients. The general arrangement of the hospital is shown in the accompanying plan. The one-storied pavilions belong to several systems. One of these is especially distinguished by its heating and ventilating system, planned by Mr. Julius Thomsen, Professor of the University and President of the Polytechnic Academy. In outline it is in each of two entirely similar halves, as follows: fresh air is conducted from wells at a proper distance from the building to an air chamber in its cellar, from which it is conducted under the floor of the sick ward, into which it ascends through three openings in the floor. In the cellar a fire is kept up all the year round; during the cold season the draught from the furnace is conducted to a chimney in the centre of the building through a calorifere placed in the air-chamber; hereby the fresh air gets a suitable temperature, while the

draught in summer is conducted directly to the chimney, without passing the calorifere. The chimney will always thus be able to exhaust the vitiated air of the sick ward, which is effected by means of channels leading

PLAN OF BLEGDAMS HOSPITAL, COPENHAGEN



to the chimney from openings in the walls of the ward at various heights from the floor. The draught in the fireplace, in which the consumption of fuel naturally varies according to outside temperature, can be regulated with a simple mechanism from the cellar, as well as from the sick ward, so that it goes partly through the calorifere, partly directly to the chimney, and that an increase of one passage corresponds to a diminishing of the other. In the same manner the exhaust can be regulated; its strength can be read from an anemometer in the ward, and it may be regulated or entirely stopped, according to circumstances. The nurses are thus at all times able to control the temperature and renewal of air. The above-mentioned two-storied sick ward of Blegdams Hospital was just completed at the expiration of 1890, and represents a high-class modern-hospital technique. The principles on which the new operating room in the Commune Hospital, above described, was built are in every essential also used in this building. Its baths, kitchens, closets and other accessories are in most perfect harmony with the principles described above.

HEALTH OF TOWNS.

HEALTH OF TOWNS.

Under this title it has been customary to present a digest of the annual reports of the local boards of health which have been received at the office of the State Board of Health.

Very few of the smaller towns (such as have populations of less than 2,000 inhabitants) publish separate reports of the local boards of health. The reports which we receive are, therefore, mainly those of the cities and large towns.

The most prominent topics which appear in these reports are the increased care devoted to the subject of the notification of infectious diseases, and their prevention by isolation, disinfection and vaccination, the need of sewerage and efficient methods of disposal in towns where no systems are in existence, the inspection of plumbing and registration of plumbers, and the disposal of the garbage and the refuse of houses and of streets.

The subject of the notification of diseases has been considered at an earlier place in this volume.

The following table contains the statistics of cases of diphtheria, scarlet fever, typhoid fever and measles reported to local boards of health, as compiled from the annual reports of such boards, which have been forwarded to the office of the State Board, since the close of the calendar year 1893. In parallel columns are also presented the deaths from the same causes, as given in the same reports.

Certain Infectious Diseases reported to Local Boards of Health in 1893.

Cities and Towns.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
Amesbury, ...	18	-	89	14	21	-	-	-
Attleborough, ...	21	5	30	1	12	-	91	-
Ayer, ...	-	-	37	-	5	-	3	-
Beverly, ...	9	1	7	-	14	2	-	-

Certain Infectious Diseases reported to Local Boards of Health in 1893 — Continued.

Cities and Towns.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
BOSTON,	1,465	476	2,580	248	824	148	-	-
Bradford,	5	1	8	-	6	1	5	-
Bridgewater,	2	-	3	-	2	-	-	-
BROCKTON,	44	15	82	5	20	3	111	-
Brookline,	18	4	44	7	10	3	515	6
CAMBRIDGE,	103	48	680	67	92	16	-	11
CHELSEA,	29	10	89	7	10	5	-	-
Concord,	7	-	38	-	4	-	43	-
Dedham,	3	-	53	3	9	2	47	-
Easthampton,	84	11	16	-	-	-	-	-
EVERETT,	10	2	105	11	12	4	147	5
FALL RIVER,	40	13	343	32	87	17	-	-
FITCHBURG,	10	3	28	-	23	4	592	7
Framingham,	13	2	32	1	-	-	38	-
Gardner,	4	-	9	1	18	1	50	2
GLOUCESTER,	16	9	110	5	7	5	-	-
Great Barrington,	4	2	27	1	-	-	-	-
Greenfield,	47	5	9	-	10	4	-	-
HAVERHILL,	18	3	97	6	58	12	26	-
Hingham,	2	-	29	4	-	-	-	-
Hudson,	4	2	14	1	14	6	13	-
Ipswich,	5	1	19	1	5	-	20	-
LAWRENCE,	85	19	241	81	141	33	60	3
Leominster,	20	2	33	1	6	1	264	-
Lexington,	1	1	2	-	2	-	154	-
LOWELL,	85	30	209	18	160	53	541	10
LYNN,	105	38	272	9	63	12	-	-
Marblehead,	15	-	113	5	7	-	-	-
MARLBOROUGH,	7	6	14	-	2	7	316	3
Maynard,	1	-	43	2	-	3	13	-
MEDFORD,	28	7	31	5	13	6	300	1
Melrose,	15	3	93	5	5	-	92	-
Millbury,	10	1	14	-	15	3	118	2
Milton,	4	-	10	-	2	-	27	-
Nantucket,	0	-	0	-	0	-	0	-
Needham,	3	-	4	-	11	3	1	-

Certain Infectious Diseases reported to Local Boards of Health in 1893 — Concluded.

Cities and Towns.	Diphtheria and Croup.		Scarlet Fever.		Typhoid Fever.		Measles.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
New Bedford,	26	13	222	8	234	29	125	5
Newburyport,	35	8	6	1	57	7	23	0
Newton,	89	33	115	2	23	4	548	1
Northampton,	15	5	77	12	49	4	26	1
North Andover,	-	-	4	-	2	-	3	-
North Attleborough,	-	2	-	14	4	3	-	-
Northbridge,	9	-	1	-	1	-	-	-
Orange,	-	1	1	-	6	2	32	-
Pittsfield,	7	1	164	4	20	5	98	2
Plymouth,	61	22	8	1	18	-	-	-
Quincy,	15	4	97	3	29	10	252	2
Reading,	1	-	3	-	3	1	23	-
Revere,	8	1	16	2	6	1	-	-
Rockland,	2	1	17	-	1	1	34	-
Salem,	47	13	79	1	52	11	-	-
Saugus,	-	-	1	-	1	-	43	-
Springfield,	48	22	285	24	52	-	-	10
Swampscott,	5	2	11	-	-	-	-	-
Taunton,	9	6	181	10	10	7	-	-
Wakefield,	21	6	33	3	10	5	53	-
Waltham,	35	12	132	3	25	2	-	-
Ware,	11	5	15	-	1	1	17	8
Wellesley,	2	-	8	-	-	-	48	-
Westborough,	-	-	4	-	-	-	-	-
Westfield,	several	1	several	-	several	6	-	-
Westford,	2	1	8	-	1	1	15	3
Williamstown,	6	1	8	4	7	3	1	-
Winchester,	4	1	15	2	12	4	250	-
Woburn,	32	8	73	9	9	1	-	-
Worcester,	123	38	179	10	148	31	1,112	16
Totals,	2,919	926	7,420	654	2,457	492	6,290	98

From the comparison of these figures, the relative fatality of each disease during the year in these cities and towns may readily be ascertained. The columns of deaths may be considered as quite accurate, while the reported cases are probably somewhat less than

the actual numbers, in consequence of a small percentage of neglect or failure to report. The figures are as follows: —

Reported cases of diphtheria and croup, ...	2,919
Registered deaths from diphtheria and croup, ...	926
Fatality, ...	31.7 per cent.
Reported cases of scarlet fever, ...	7,420
Registered deaths from scarlet fever, ...	654
Fatality, ...	8.8 per cent.
Reported cases of typhoid fever, ...	2,457
Registered deaths from typhoid fever, ...	492
Fatality, ...	20.0 per cent.
Reported cases of measles, ...	6,290
Registered deaths from measles, ...	98
Fatality, ...	1.6 per cent.

The following summary contains the figures for each of these diseases for the years 1891, 1892 and 1893: —

Reported Cases of Infectious Diseases.

	Diphtheria and Croup.			Scarlet Fever.			Typhoid Fever.			Measles.		
	1891.	1892.	1893.	1891.	1892.	1893.	1891.	1892.	1893.	1891.	1892.	1893.
Reported cases, . .	2,444	3,033	2,919	4,517	6,112	7,420	2,414	1,892	2,457	5,861	783	6,290
Deaths, ...	575	891	926	151	281	624	460	435	492	84	31	98
Fatality, . . .	23.5	29.2	31.7	3.3	4.6	8.8	19.0	23.0	20.0	1.4	4.0	1.6
Mean of three years,	28.5			5.8			20.5			1.6		

The cities and towns embraced in this list were 70 in number, and comprised about three-fourths of the population of the State. They were nearly identical with those which furnished reports in 1892.

The number of reported cases of diphtheria was eighty less than that of 1892, and the percentage of fatal cases was slightly larger.

The reported cases of scarlet fever exceeded those of 1892 by 1,308, while the fatality was 8.8 per cent. or nearly double that of the preceding year.

The reported cases of typhoid fever were greater than those of 1892 by 565, but the fatality was less, being 20 per cent. as compared with 23.0 in the preceding year.

The reported cases of measles were eight times as many as those of 1892, but the fatality was less than half as great, being 1.6 per cent. as compared with 4.0 in the preceding year.

The following figures present the fatality from diphtheria, scarlet fever and typhoid fever as reported by the Local Government Board of England for the years 1890, 1891 and 1892.

	1890.	1891.	1892.
Diphtheria,	25.5	23.7	23.6
Scarlet fever,	8.0	5.8	4.4
Typhoid fever,	19.9	20.8	17.8

Amesbury.

There have been many less complaints entered this year than last, eighty-two cases as against one hundred and fifty. Most of these were promptly abated on the attention of the property owners being called to the unsanitary conditions, therefore little expense was incurred to have official notices served.

There was some delay in abating the odor from the old soap factory, but the exigencies of the business made it almost unavoidable.

The Board would again call the earnest consideration of the voters of the town to the utility and economy of sewering the town, as per plan now on file; if not the whole, at least a part should be done every year.

Scarlet fever at first showed itself in a mild form, but has gradually assumed a more malignant type, with a death rate of sixteen per cent. of reported cases. To stay the spread of this dread disease, the Board has promptly placarded every house in which the disease has been reported, and given full instructions as to the importance of isolation and proper disinfection. Some physicians and most heads of families have been dilatory in reporting the cases, and some were not reported at all. The State law requires such reports to be made, and imposes heavy fines for neglect. The school committee had the public schools closed for some weeks to stay the progress, but with no perceptible benefit, as two days before re-opening

Arlington.

In the absence of a regularly elected Board of Health, the selectmen, under the statutes, constitute the Board. As our town increases in population, and dwellings are erected nearer together, the importance of an alert and competent Board of Health is evident. On all our streets a greater or less portion of the land is used for cultivation. This results in the use of various forms of fertilizers, which, while not always dangerous to health, are very objectionable — whole neighborhoods at times being rendered uncomfortable by the unloading of the refuse from the city.

The keeping of swine within the limits of the town should be restricted to places remote from the densely inhabited portions.

We suggest that a separate Board of Health be elected by the town, selected from those citizens who are especially familiar with sanitary matters.

Attleborough.

In accordance with the requirements of the Public Statutes, the Board of Health makes an annual report to the town. This report should include an account of the duties performed by the members, such suggestions for the physical welfare of the town as occur to them as the results of their experience, and tables of vital statistics which, when compared with reports of former years, indicate the way the town is growing and suggest opportunities for its sanitary improvement.

Less complaints were received this year than usual. In fact, householders are now generally informed as to the requirements of the Board and gladly conform to them. No serious epidemic has occurred.

Measles became so prevalent that the Board requested the school committee to exclude from the public schools all pupils coming from homes where there were such cases. This, being an innovation, caused unfavorable criticism from the public and even from physicians in town, but singularly enough, by this action the local Board only anticipated by a few months what is now required by the statutes, viz., that measles shall be included in the list of diseases "dangerous to the public health," and consequently to be especially guarded against.

Ayer.

The most notable occurrence in connection with the health of the town, during the year, was an epidemic of scarlet fever. The lower grades of the public schools were closed for several weeks in December with little apparent effect in checking the spread of the disease. The disease was probably spread in many instances by cases so mild they were not recognized.

Barre.

It is a notable fact relative to the health of Barre, that, in a total of thirty-five births and thirty-six deaths, there were no deaths of infants, and no death was reported of any person under thirty years of age.

Beverly.

There was free vaccination of 1,374 patients, and the issuing of certificates to the same.

In view of the fact that the town has voted to put in a system of sewerage, the Board would most earnestly recommend that the town adopt the State plumbing law so that in the future the citizens will receive the full benefit of the sewer.

They would also call attention to the daily increasing demand for the adoption of some system for the collection of garbage, swill and ashes. At the present time the greater part of the swill is mixed with ashes and then dumped on some of the various dumps in and about the town, thus creating a very undesirable state of affairs in such locations.

Boston.

The total number of deaths during the year was 11,710, an increase of 474 over the preceding year. The death-rate per 1,000 inhabitants for the year is found to be 24.02. The prevalence of pneumonia during the year assumed a character unequalled in the registration of vital statistics in this city. In 1851 its percentage to the total mortality was 7.75; in 1893 it was 13.15 per cent., or a total of 1,540 deaths from this cause alone. It is gratifying, however, to be able to state that the percentage of the total mortality from zymotic causes is less by .49 per cent. than for the year 1892, or 17.43 per cent. of the total number of deaths. The deaths from diphtheria increased 62, while the deaths from scarlatina decreased 14, as compared with the preceding year.

Infectious Diseases.

Small-pox. — On Oct. 30, 1893, after an interval of fourteen months, a case of small-pox occurred in Ward 6. The patient, a boy eleven years old, who arrived in Boston, October 15, on the "Catalonia," must have contracted the disease on that steamer. On November 6 a second case occurred. The case was found in Ward 22, and was directly traceable to the "Catalonia." This patient was removed to the hospital, and as he was unvaccinated he had a severe attack of the disease. This case gave rise to two others occurring in this man's family. As the two last patients had been vaccinated they were not very ill, and remained at the hospital only a short time. On November 13, in Ward 13, three cases occurred in one family, which were

directly traced to a mild attack of the disease which must have been contracted on the "Catalonia." These three patients, together with the person who arrived on the "Catalonia," were removed to the hospital, where they all recovered. The unvaccinated were quite ill; the vaccinated were not seriously ill. On November 18 a case occurred in Ward 14. The patient, a little girl about three years old, contracted the disease from a mild case in a person who arrived in Boston on the "Catalonia." On December 7, 8 and 9 eight cases occurred in Ward 19, which were contracted from an unrecognized and mild attack of the disease. A case occurred on December 8, in Ward 18, the origin of which could not be traced. From Dec. 10, 1893, to Jan. 5, 1894, eleven cases occurred which could be directly traced to the mild case in the family living in Ward 19, which has been previously mentioned. On December 13 a case occurred in Ward 14, which could be directly traced to a previous case.

From Oct. 30, 1893, to Jan. 31, 1894, there were in all thirty-six cases. The percentage of deaths among the unvaccinated has been 29.62. No vaccinated person has died, and no vaccinated person has been seriously ill. A mother nursed her infant, who had the disease, during the whole course of the attack, but as the mother had two perfectly characteristic scars she did not contract the disease. Two vaccinated children, relatives of a patient, were constantly exposed from three to four weeks to the disease and did not become ill.

Vaccination. — The number of cases of small-pox having increased in November, it was thought best to offer free vaccination in those sections of the city where cases of this disease were most frequently found, and there were in round numbers 100,000 vaccinated.

Early in November, while vaccinating among school children in South Boston, the Board personally discovered the fact that many children were attending the public schools without ever having been vaccinated, and these facts were subsequently communicated to the School Committee, under date of Nov. 28, 1893. Fifty-nine thousand four hundred and eighty-eight pupils have been examined; there have been 4,120 primary vaccinations; 10,152 re-vaccinations; and the number of pupils refusing vaccination and presenting insufficient evidence of having been vaccinated is 1,678.

Diphtheria. — The Board of Health has repeatedly asked for an appropriation with which to increase its care for the uncontrolled cases of diphtheria and scarlet fever, and it has as often been refused. The Board would like to have all cases seen by its own physicians or agents, held under proper surveillance while at home, and released from isolation only on the certificates from the same physicians or agents. We would like to aid in having all doubtful cases of sore throat decided by expert bacteriological examinations, and have all cases of diphtheria discharged from isolation by means of the same tests, or after a prolonged isolation when all local and general symptoms of the disease have disappeared. To do this the department

must have more medical agents, and have its present medical officers relieved from duties now performed for other departments of the city.

We have long since been satisfied that the welfare of the schools and the community at large demands better protection against the spread of contagious diseases, and that through additional medical agency alone can we hope to give such protection.

For this purpose the Board of Health recommended to the School Committee the adoption of the following regulations in response to a request from the School Committee: —

First: That no pupil be admitted to any public schools without a certificate from ______________ that such pupil bears the physical evidence of having had a disease known as vaccinia.

Second: For the return of any pupil to school after suffering from small-pox, scarlet fever, diphtheria, measles, or whooping-cough, a certificate should be required from __________ that the pupil has lost all power to communicate to others the disease from which he has been suffering, and that all infected articles of his household have been disinfected to the satisfaction of the Board of Health. For the continuance of any pupil in school in whose family or in whose proximity there is a case of small-pox, scarlet fever, diphtheria, or measles, or any undestroyed infection or contagion from said diseases, there should be required a certificate from __________ setting forth the fact that the patient is safely removed from the danger of contracting and of conveying the disease.

When a child is known to have been exposed to the infection of small-pox, scarlet fever, diphtheria, or measles, it should return to school only on certificate of __________ that the period of incubation belonging to the disease to which he has been exposed has passed.

Houses Vacated.

During the year one hundred and eighteen houses have been ordered vacated for various causes, the chief complaints being general unsanitary conditions and want of repair. These houses were for the most part tenement-houses located in different sections of the city.

Tenement and Lodging House Inspection.

During the night visits of the inspectors the present winter, many cases of overcrowding were discovered in tenement-houses in the poorer sections of the city.

This the Board has been obliged to remedy by ordering the removal of all the occupants of such tenements, as it is obviously impossible for the Board to determine which ones should be allowed to remain, and which compelled to go. This difficulty, however, was in many cases solved by the occupants themselves, and as soon as the number of occupants became reduced to a satisfactory limit the Board rescinded its order to vacate the

premises if other sanitary requirements were complied with; in a few instances, however, the premises had to be entirely vacated before a satisfactory condition was reached.

The cheap lodging-houses have been frequently visited, and in most cases all requirements of the Board were complied with.

House to House Inspection.

Whole number examined,	382
Bad odors found in,	83
Defective drains found in,	122
Defective trapping found in,	107
Privy-vaults found,	3
Offensive vaults found,	3
Damp or unclean yards,	8
Damp or unclean cellars,	14
Using furnaces,	190
Furnaces without proper air-supply,	18
Using steam-heat or hot water,	28
Water-closets found in,	377
Offensive water-closets found in,	18
Ventilation to soil-pipe or drain found in,	250
Offensive cesspools found,	13
Percentage of defective drains,	31.94
Percentage of defective trapping,	28.01
Percentage of unventilated drains,	34.55

Pollution of Charles River.

In the fall of 1892 a complete inspection and report were made by a corps of inspectors from this office of all the drainage which was a source of pollution to the Charles River. This report includes all that part of the river located in Ward 25, and embraces not only the public sewers but also all private drains, the discharges from which, either directly or indirectly, eventually find their way into the river. At the time of inspection, in 1892, there were 232 private drains reported as discharging directly or indirectly into the river.

Public Baths.

The following table shows the number of bathers at the public baths:—

	1892.	1893.
Total men and boys,	908,889	825,614
Total women and girls,	216,947	181,864
Total of both sexes,	1,125,836	1,007,478

Disinfection.

The following tables show the work of disinfection during the year: —

Diphtheria,	1,307	Infected books,	23
Scarlet fever,	2,235	Infected carriages,	28
Typhoid fever,	3	Cancer,	2
Measles,	17	Miscellaneous,	2
Small-pox,	20		
Infected clothing and bedding,	79	Total,	3,716

Number of rooms, 6,429.

Streets,	429	Water-closets,	9,522
Places,	743	Passageways,	5,510
Courts,	564	Urinals,	389
Alleys,	3,803	Vacant lots,	525
Yards,	17,415	Filthy sheds,	7,509
Vaults,	4,413	Filthy rooms,	2,965
Cellars,	10,656	Sinks,	9,739
Cesspools,	18,723		
Gutters,	11,004	Total,	103,909

Material used: bichloride of mercury, 1,550 pounds; chloride of lime, 54 casks; sulphur, 31,671½ pounds; copperas, 22 barrels; and 7 barrels of other disinfecting powder.

Nuisances.

The total number of nuisances abated during the year is 8,447.

In addition to the foregoing there have been 930 complaints investigated where action by the Board was found to be unnecessary.

Report of Physician to the Board of Health.

There have been 4,332 persons vaccinated, and certificates of vaccination have been given to 3,416 children for their admission to the public schools.

At the request of the Civil Service Commission three hundred and eighty-eight men have been examined for appointment in the Police and in the Fire Departments.

The bodies of six hundred and nineteen persons dying without a physician in attendance have been examined. These cases comprise principally those who die from chronic diseases, where there has been no medical care for months previous to death, and those who die suddenly from natural causes. In these a careful external examination is made, the symptoms learned, and a diagnosis, sufficiently accurate for all practical purposes, reached.

Ninety-six cases of eruptive disease reported as small-pox have been examined. Of these, twenty-six were found to be small-pox, and the patients — five men, thirteen women and eight children — were removed to the small-pox hospital on Canterbury street, where twenty-two recovered. The manifest importance of a bacteriological investigation as a means of diagnosis in doubtful cases of diphtheria is becoming more and more evident, and of no less importance, as far as the well-being of the community is concerned, is the bacteriological investigation of cases after apparent recovery from diphtheria. In an endeavor to diminish the prevalence of this disease, the two most important factors are: first, the recognition of mild and doubtful cases; second, the actual disappearance of the specific germs of the disease, which can only be recognized by means of a bacteriological investigation.

Report of Port Physician.

During the entire year all vessels arriving from the following ports were stopped at this quarantine for inspection: from all ports in Europe; from the Western, Madeira, Canary, or Cape Verde islands; from the Mediterranean sea or straits thereof; from the west coast of Africa or around the Cape of Good Hope, and from Central and South America.

From the first of June, vessels from the West India, Bahama, or Bermuda islands, and Mexico were stopped for inspection.

From the first of June to the first of November, all vessels arriving from any port in the United States south of Virginia were inspected at this quarantine.

Eight hundred and sixty-one vessels were boarded during the year.

Number of vessels disinfected, eight; one of which was a schooner and the remainder were steamers.

Number of persons removed from vessels for sickness, seventeen.

Number of persons vaccinated, 2,855.

The new bath-house and disinfecting cylinder were used for the first time April 1, and they both worked satisfactorily.

Report of Inspector at Abattoir.

Animals Killed.

Cattle,	34,521
Calves,	6,540
Sheep,	63,029
Total,	104,090

Animals Condemned.

	Number.	Weight.
		Pounds.
Cows, ...	29	12,437
Steers, ...	4	3,140
Bulls, ...	2	1,700
Calves, ...	[illegible]	270
Sheep, ...	3	130
Parts of animals, ...	–	2,500
Total, ...	44	20,177

Tuberculosis.

Fifty cases of tuberculosis were detected among adult cattle.

The following table shows the percentage of tuberculosis among cattle killed with the intention of being used for food: —

Class of Animals.	Number Received.	Tuberculosis.	Percentage.
Whole number of all kinds, ...	34,521	50	0.14
Cows from eastern states, ...	2,014	44	2.18
Cows from western states, ...	–	3	–
Cows known to be from Massachusetts, . .	1,350	39	2.88
Steers from western states, ...	–	–	–
Oxen from eastern states, ...	–	2	–
Bulls, ...	–	1	–

Inspection of Cattle.

The work of inspection of cows, as provided for by the Board of Health, and subsequently made compulsory upon cattle in general by an act of the legislature, has been continued during the past year. There are within the city limits about 2,400 cattle, distributed in about 690 barns; all of these

slightest idea of cleanliness, and practise little or none in the production of milk. Unfortunately a great many of such people are dependent on the sale of milk for a livelihood.

Bradford.

One case of tuberculosis has been reported, which was at once sent to the Cattle Commissioners, and the cow isolated as required by them and was, after examination by them, ordered to be killed.

The following regulation was drawn up and accepted by the Board and posted by them in accordance with the Public Statutes.

Regulation 40: No person shall keep swine or goats within the compact part of the town without a license from the Board of Health; and no swine shall be kept within three rods of any dwelling elsewhere.

There have been seventy houses where new plumbing has been done, and the inspector has thoroughly examined and accepted the same.

It is our advice that the town employ responsible parties, who shall, at stated intervals, collect the ashes and take charge of the dumping places, and that a contract be made with some responsible party to collect the swill and garbage as often as twice a week.

Braintree.

By provision of law in towns not having a Board of Health, the selectmen act as such, having all the authority bestowed upon such Board. As the town is becoming more densely populated, stricter attention should be paid to the sanitary conditions.

We believe that the carrying of curtains or canopies from house to house as is sometimes the custom of funeral undertakers is a frequent source of contagion, and the practice should be discountenanced.

Brockton.

The following is a list of the principal complaints and nuisances investigated during the year: —

Defective cess-pools,	102
Defective vaults,	65
Filthy yards,	115
Houses placarded,	126

The number of loads of cess-pool matter removed by the excavator wagons the past year was 12,210; the number of loads of night-soil removed was 3,099; the number of loads of ashes removed was 5,444.

The Sewerage Commissioners have completed the part of the work laid out for the year 1893, and, if as successful in carrying out their plans for sewering the streets, will be able to take care of the sewage of the business part of the city the coming year.

A requisition was made upon the Civil Service Board of Examiners for a list of plumbers qualified for the position of inspector of plumbing. The names of three persons qualified to fill the position were certified to this Board, and one was selected and appointed by the Board as inspector of plumbing.

Brookline.

The number of deaths reported from tuberculosis during the year (thirty, or over 12.5 per cent. of all the deaths, occurring principally as consumption), shows the need on the part of the public of a clearer understanding of the preventable nature of this too common disease. It may not be out of place to emphasize the fact that pulmonary tuberculosis (consumption) is absolutely proven to be a communicable disease, and quite easily communicated when the person exposed to it has his vitality depressed by such influences as foul air, indoor occupation, food poor in quality or insufficient in quality, bad ventilation, certain climatic conditions and especially fatigue from nursing a consumptive.

In April, the following order was passed: —

Ordered, That in case of death, when the deceased has not been attended by a physician, the certificate of death shall be issued by the Medical Examiner.

The public swimming-bath on Boylston street was open as usual during June, July, August and September. Early in the season the portion of the brook above the bath-house was inspected and cleaned out, and measures were taken to prevent pollution of the stream. Some necessary repairs were made on the bath-house to enable it to be used a little longer. Supt. Dillon reports that during the season 9,790 baths were taken, an increase of 2,101 over the previous year. Neither accidents nor illness have been reported, and many boys have learned to swim.

The importance, as a health measure, of frequent bathing in hot weather, and the great value of a public swimming-bath, both as a means of physical culture and of acquiring an art the possession of which saves many lives, can hardly be overestimated. The recommendation made last year by the committee on the bath-house is renewed, namely, that a more commodious swimming-bath be constructed.

The occasional need of a suitable building, owned by the town, for persons taken ill with diphtheria, scarlet fever or other dangerous contagious diseases (except small-pox) and having no home here, has received careful attention and it was

Voted, That in the opinion of the Board, it is necessary to erect a separate building upon land owned by the town, adjacent to the almshouse, for the care and treatment of patients with contagious diseases.

The emergency hospital for cases of small-pox, built by the Board in 1885, and fortunately never needed until 1893, was put in condition for patients, and, most important of all, ample facilities were provided for free vaccination.

Of the nine hundred and seventy-five persons who received free vaccination between December 1 and January 31, a very large proportion were natives of the British Provinces and never previously vaccinated. A number of alleged cases of small-pox, and of persons reliably reported as recently exposed to that disease, were promptly but quietly investigated by the Board, and all necessary precautions were taken in each case.

CAMBRIDGE.

Complaints and nuisances investigated during the year: —

Full, overflowing and offensive privy vaults,	733
Offensive and defective water-closets,	28
Defective drainage, open and broken drains, etc.,	61
Filthy yards,	118
Number of inspections made,	6,368
Number of subsequent inspections,	4,020
Total,	10,388

Number of notices issued and recorded,	1,070
Number of visits to premises where contagious diseases occurred during the year,	1,644

The various dumps throughout the city have caused considerable annoyance and given rise to many complaints during the year. With a view to a more thorough control of the persons using these dumps and for the prevention of the deposit of improper material on them, the Board decided to employ a mounted police officer for as long a time as the appropriation at their disposal would permit. The short experience the Board has had with this means of prevention, has convinced it of its value.

Owing to the occurrence of some cases of small-pox in neighboring places, the Board decided to open three stations for free vaccination. Following is a list of vaccinations done up to the close of the year: — Station One, seventy-one; Station Two, two hundred and four; Station Three, one hundred and fourteen.

An unusual prevalence of scarlet fever, or of diphtheria, always raises a question of the expediency of closing the public schools. Setting aside the fact that Boards of Health have not this power, it does not appear as if such a proceeding would answer any useful purpose in the majority of cases in such a city as Cambridge. Any plan calculated to control effectively the spread of such diseases as scarlet fever and diphtheria must include the following measures: —

1. *Isolation.* Hospital accommodation will be required for those cases which cannot be properly isolated at home.

2. *Disinfection.* Carpets, bedding, clothing and such like articles can be disinfected by steam. This requires a proper plant.

3. Articles of little value that have been exposed to contamination should be burned.

4. The floor and woodwork of rooms should be well scrubbed with soap and hot water. Walls, ceilings, chairs, bedsteads and such other pieces of furniture should be thoroughly wiped with damp cloths, and the cloths burned.

5. Windows should be left open for several days. Fresh air and sunlight are among the most effective of purifiers

Burning sulphur, or the evolution of chlorine fumes, is a useful adjunct, but they cannot take the place of the measures mentioned above, and to rely on them is, in our opinion, a grave mistake. Disinfection means a process by which disease-producing micro-organisms are killed. It does not mean deodorization, nor does it mean the substitution of one smell for another smell. It is one thing to kill germs in a test tube; to do this in a room with all its cracks and corners and its unavoidable leakage is a very different business.

The mortality per 1,000 living, at all ages, was 19.72.

Chelsea.

Under the act of 1890, which was accepted by the city council, three hundred and sixty-eight privies have been abolished this year, and the work will be continued the coming year, where, in the judgment of the Board, it is necessary.

Owing to the breaking out of small-pox in Boston it was thought best, as a precaution, to advertise free vaccination, which began the twentieth of December.

Concord.

It was thought best by the Board, after careful consideration, to stop all direct drainage into the river in this town.

Regulations were made by the Board relative to school attendance in time of prevalence of infectious diseases.

There have been two cases of glanders in this town the past year. In both of these cases the horses have been killed as soon as a positive diagnosis was given by the attending veterinary.

We make the following recommendations, and hope the town will take action on the same: —

That a system of sewage disposal of some kind other than the present be put in at once.

That some suitable piece of land be bought by the town to be used by the inhabitants of this town as a dump. Some place should be procured

far enough away from the centre of the town, off from the main roads, to which every one should cart his rubbish, ashes, tin cans, etc. No garbage of any kind should be allowed to be dumped there, and the place should be burned over once or twice a year. The places now used are unsightly, if not dangerous to public health.

That the board of health of this town consist of three members, one of whom to be elected annually, to serve three years, to be separate and distinct from the selectmen.

Cottage City.

During last August our attention was called to the condition of the waters of Lake Anthony. On investigation we found the opening through the beach to the sea nearly closed, and the water becoming stagnant had allowed the sea-grass and moss to grow in large quantity. Although not unhealthy, it has an unpleasant odor, and renders unsightly what is otherwise a beautiful sheet of water. We recommend the appropriation of a sum not exceeding one hundred dollars for the purpose of cleaning the shore of the lake and maintaining a sufficient opening to the sea.

To conform to the requirements of chapter 195 of the Acts and Resolves of the year 1892 we appointed an inspector of provisions and of animals intended for slaughter or kept for the production of milk.

Dedham.

There has been a great increase in the scarlet fever cases over previous years. Considerable care has been taken by the Board to prevent the spread of this disease, and the scattered and wide range of the cases rendered it practically impossible for the Board to anticipate results. Many of the cases were traced by the attending physician to outside sources, and beyond the control of the Board. It has been found almost impossible, in some cases, to make the parents understand the value of implicitly following the instructions given by the attending physician, and in one case it became necessary to enforce directions by means of an officer. The three deaths were all in one family where the cases were severest.

The reporting of the cases of measles has heretofore not been insisted upon. The value of such a report is chiefly for the use of the superintendent of schools in relation to attendance of pupils afflicted or exposed to this disease.

A large proportion of the complaints made to the Board during the previous year were from the keeping of swine in the more thickly-settled portion of the village. It was found difficult to allow the keeping of swine in certain localities without their being a nuisance. In consequence the Board adopted the regulations now in force, prohibiting the keeping of swine within the more settled portions of the village, with the result that the complaints and nuisances from this source ceased. Under the present

idea that swine must be kept in filth and mire the Board believes that the prohibition of their keeping in the closely-settled portions of the town is the only method whereby this nuisance can be disposed of satisfactorily.

The town must, at a very early date, take the question of sewerage seriously under consideration. Each year the demand grows more imperative. It needs but the inspection of a majority of cess-pools in this town to convince one of the necessity of a more sanitary and efficient method. The cost of caring for these unsightly and unsanitary receptacles is as great, if not greater, than would be the expense to the town of an efficient sewerage system. Many cess-pools are becoming choked up, and are merely cisterns to be cleaned out often at great expense and discomfort, or else allowed to overflow as a continual menace to health. It is earnestly hoped that the town will take immediate action in relation to the sewerage question.

In accordance with chapter 477 of the Acts of 1893 the Board has prepared a set of by-laws for the consideration of the town in relation to the regulation of plumbing and plumbers.

A matter of considerable importance has been brought before the Board this year in relation to the better drainage of Wigwam meadows and Little Wigwam swamp. This subject has been before the town for many years, and has been reported on by previous boards of health and committees. While such reports have been unanimously in favor of improving this drainage, little has been done in this direction except to clear a ditch from Wigwam pond to the river. After a hearing and careful examination of the locality in company with some of the petitioners the Board decided that a careful survey and thorough examination of the swamps and facilities for better drainage should be made as a guide for a proper consideration of the subject. In accordance with this, plans and a report with estimates have been prepared which treat the whole matter in an exhaustive and thorough manner. This report is annexed to the report of the Board.

East Bridgewater.

The Board has visited several scarlet fever cases this year, and has seen to it that no persons passed in and out of the houses where such cases existed, except those who were absolutely obliged to do so. We have, also, visited several horses, and have condemned one as affected with glanders and ordered him disposed of. We have also examined and quarantined several tuberculous cattle, and shall see that they are also properly disposed of before their milk and flesh have infected healthy human beings. The Board has also corrected several extreme nuisances.

Easthampton.

There have been comparatively few complaints of the existence of nuisances as compared with former years. People generally evince a readi-

generally realize that it is for their own benefit to keep their premises in a neat and cleanly manner.

With the contemplated and partially constructed sewer system and the introduction of an abundance of pure water into more general use we are confident that the appearance of contagious diseases will be greatly lessened.

Everett.

The city has been remarkably free from summer diseases of children. There was an increase in the number of cases of some of the zymotic diseases. Cards have been put on the houses wherever there was a case of diphtheria or scarlet fever, and notice sent to the school committee, public library and State Board of Health.

Everett is a city of new houses. It will be a matter of a great deal of public importance to learn how many persons become sick with consumption while living in these new dwellings, or, in case of death from that disease, to learn if the person was afflicted before coming here. The Board has taken steps to obtain, as far as possible, and record these facts.

The Board has fumigated houses after contagious diseases when requested to do so. As the disinfecting done by householders is, in most cases, worse than useless, since it is often thought that the burning of one or two ounces of sulphur has destroyed all germs and no further precautions are necessary, the Board voted that, beginning with Jan. 1, 1894, all houses where contagious diseases had occurred should be disinfected by, or under, the personal direction of the Board or its agent.

Fall River.

It is especially gratifying to note that the exceptional decrease in typhoid fever cases observed in the returns for the year 1892 has been maintained during the year 1893. The sanitary education of our citizens is undoubtedly making great improvement. The limitation of the spread of contagious diseases has been helped very much by the fact that early in the year this Board adopted the system of immediately placarding every house in which a case of scarlet fever or diphtheria was reported to exist, and ordering that the cards remain in place until two weeks after the recovery, removal or death of such patient or patients. We would recommend that, even though we have no reason to be apprehensive of a cholera visitation, a house-to-house inspection every spring would result in a benefit to the public health, fully justifying the necessary outlay. It is our opinion that provision should at once be made for an annual visitation of this kind. We know that such a yearly stirring up and cleaning of the city is absolutely necessary. Experience has taught us that it is only by such system-

atic inspections, the sources of all nuisances can be successfully located and the city kept in a thorough sanitary condition.

Number of live cattle examined,	1,325
Number of live cattle examined and reported as unfit for food or food supply,	6
Number of meat carcasses examined,	26
Number of meat carcasses examined and destroyed,	15

The following is a summary of the work accomplished in the office of the Inspector of Plumbing during the year just ended: —

Number of plans filed,	471
Number of new houses,	268
Number of reconstructions,	203
Number of approvals,	425
Number of inspections,	1,899

Fitchburg.

During the past year the city has been visited with one of the most extensive epidemics of measles in its history, there being 592 cases reported to the Board. The disease was not of a severe form, and the number reported did not express the total number of cases. It began in January and rapidly increased until May, when 270 cases were reported. It as rapidly declined during the summer, and in August only one case was reported.

In regard to diphtheria the number of cases was ten, and was below the average for the past four years, during which time the records have been carefully kept, the average being 14.5 for the period. The cases showed a milder form than usual, there being only three deaths, one of which was called croup. The largest number of cases occurred in the first three months of the year, conforming to the average for four years.

There were twenty-eight cases of scarlet fever reported, as compared with fifty-one for 1892, and an average of sixty cases for the four-year period. The cases were unusually light, no deaths from the disease being recorded. The largest number of cases reported was in June. This does not conform to the average for four years, during which time the largest number of cases have been reported during the first months of the year, February showing the largest number of any single month.

During the year just past there have been twenty-three cases of typhoid fever reported, the largest number for four years, and six more than in 1892, when seventeen cases were reported. There were four deaths reported as compared with none for 1892. The largest number of cases occurred in September. A comparison of the records for the four years

past shows but few cases occurring during the first six months of the year, July, September, October and November showing the largest number.

The house-offal teams have been continued in the work of collecting swill as in the previous four years, doing good work in promoting cleanliness of the city. During the past year 363 cords of house offal have been collected and carried to the place of deposit.

The rules relating to plumbing have been carefully revised to keep pace with the science of plumbing and house drainage. The result of the work of the Board for the past year shows a vast improvement in the quality of plumbing work, and still better results are hoped for the coming year.

Complaints received,	272
Privy vaults discontinued,	114
Plumbing jobs inspected,	362
New water-closets inspected,	513
Houses fumigated or instruction given,	181

Framingham.

Fifty-five complaints of existing nuisances have been made to the Board during the past year, all of which have been attended to and abated as far as was thought best. The owners of fifty-three tenements have been ordered to connect them with the public sewer.

Gardner.

Realizing the great importance of milk as an article of food, early during the past season we requested the co-operation of some of our neighboring towns in a closer inspection of the milk that was being delivered in this town; failing in this, we would recommend that no person be granted a license to sell milk in Gardner unless such person furnish an acceptable certificate of cattle inspection.

The work of the cattle inspectors during the year has added much toward the improvement of the milk. They examined thirty-three herds, three herds more than last year. Some cows were examined five times. The inspectors condemned and caused to be killed eight cows, and condemned four carcasses. At the present time all the cows in town are considered in very good condition.

We would earnestly recommend to every family who depend on wells for their supply, or for the supply of their cattle, to use the greatest possible care of their wells, and avoid all possible contamination from cesspools, water-closets and barns, or other filthy matter. By doing so they will in a great measure protect themselves from typhoid fever.

We have to report quite an extensive epidemic of typhoid fever, but rather mild in its character, and fortunately resulting in only one death. We believe that had the Board known earlier the existing circumstances this epidemic might have been somewhat lessened. As soon as the Board

investigated and found the source of infection the epidemic was confined to a very small radius, and soon brought under control. It resulted from impure milk occasioned by impure water.

Gloucester.

One hundred and ninety-three nuisances received attention. All *bona fide* nuisances have been abated where possible, but in a city without sewerage it is occasionally advisable to be very lenient, especially where some neighboring quarrel seems to have been the animus of the complaint, which sometimes appears to be the case.

If sewerage is not soon adopted the city must resort to some method less objectionable than the present method of disposing of night-soil and sink-waste.

Great Barrington.

During the year the selectmen, acting as a board of health, have been notified of twenty-seven cases of scarlet-fever, of which but one proved fatal; and four cases of diphtheria, of which number two cases proved fatal. The board adopted the usual sanitary measures of precaution in such cases. We believe that the cause of many of these cases exists in the carelessness on the part of individual families in the disposal of garbage and neglect to keep the dwellings properly cleaned. Dirt and refuse matter are two great enemies to public health, and we cannot urge too strongly the importance of an observation of the utmost care in these measures.

Greenfield.

The Board feels that the most important matter they have to recommend to the careful consideration of the town is the subject of sewers. This is a very broad subject and difficult and impossible for us to treat in the thorough manner that it demands. Our present system, if system it can be called, is totally inadequate for the needs of our growing town; many sections are entirely unprovided for, and many other sections where there already is a public sewer, suffer great expense and inconvenience at the time of a heavy rainfall, owing to the inability of the tile to carry off the large amount of surface water that is thrown into it, and in consequence cellars are flooded. This difficulty is experienced more or less throughout the whole town and sooner or later the surface water will have to be taken care of in some other way.

Haverhill.

The appointment of an inspector of plumbing has been a great relief to the agent, and great public good will be the outcome, for, as we have already stated in previous reports, it is found impossible for the agent, in addition to his other duties, to give this branch of the sanitary service, so extremely important, the attention and careful supervision that it should have. Plumbers are now required to test their work by water pressure in

the presence of the inspector, which gives a much more thorough and satisfactory inspection. The record shows that three hundred jobs of plumbing (new and remodelled) have been inspected last year.

Nuisances Investigated During the Year.

Garbage collected, loads,	1,320
House sewerage defective,	42
Plumbing defective,	30
Privy-vaults full and offensive,	138
Privy-vaults cleaned,	300
Privy-vaults removed,	142
Whole number of privy-vaults removed since 1888,	1,002

The general health of the city during the year has been excellent. No fatal epidemic has visited the city.

The faithfulness and care with which contagious diseases are reported by physicians speak well for the interest in their profession and in the public welfare. Notwithstanding the wide publicity that has been given to the law that requires householders as well as physicians to report dangerous contagious diseases to the Board of Health, some cases occur where the disease is so mild that the children are hardly considered ill enough to be put to bed, and consequently no physician is called and no report comes to the Board. Thus no efforts are made to prevent its spread, and great damage is liable to be done in consequence by spreading the disease in the neighborhood in a malignant form.

Hingham.

Early in August, complaints having reached the Board regarding a tallow factory at Fort Hill, representatives of the Board visited the establishment, which they found in a filthy condition.

The business seemed necessarily to give rise to offensive odors, and although the health of the community should always be paramount to the pecuniary interest of any individual or firm, at the earnest request of the proprietor a further time was granted on the plea that the business had but recently been established and the firm had been unable to put their manufactory into proper shape. The claim was also made by the proprietors that they, by undergoing a larger expense, could use apparatus by which all offensive odors would be destroyed. They promised to introduce such machinery at once, and an opportunity was given them to make such changes.

The establishment was several times visited by members of the Board, to watch the results of any changes made by the proprietors. On September 22, no better results having been obtained, the business was declared a nuisance by this Board, and they were ordered to close their works at once, which order was promptly obeyed.

Holyoke.

The past year throughout the city has been fairly healthy. None of the contagious diseases have prevailed at any time to an alarming extent. Although there were numerous cases of diphtheria and scarlet fever during the first four months of the municipal year just ended the number of cases during the rest of the year and at present is much below the average.

Small-pox again appeared in our midst during the month of September. Although limited to a single block, it attacked three persons, all of whom recovered after a more or less protracted stay at the pest-house. Here again the city physician desires to call your attention to, and to emphasize a recommendation of the Board of Health, viz., that there be a general vaccination. The Board of Health calls your attention to a deficiency in the heating apparatus at the pest-house. That such a deficiency exists was only too apparent during the stay of the recent cases, and, added to this, was a failure in the water supply. The water at the pest-house, obtained from a well sunk beneath the kitchen, has always been of a very poor quality, but this year it became so impure it had to be discarded even for washing purposes.

We have been remarkably free from typhoid fever during the entire year.

The Board this year as heretofore recommends that all the alleys be graded, and that those between our principal business streets, through which heavy truck-teams pass, be paved with stone, brick or any other material which seems proper.

Hudson.

The greatly increased number of calls to look after nuisances caused by the disposal of waste water, has convinced the Board that the time has come when the town ought to take initial action with regard to a system of sewerage. When all the water used by consumers is pumped or drawn from wells, the quantity used may be easily disposed of in cesspools, and taken care of by the surrounding earth without danger of infection, if the cesspools are emptied and cleaned periodically. Or, if the waste water is discharged into natural waterways, it may cause no nuisance in a sparsely settled locality, or if there are only a few discharge pipes. But, when an abundant supply is furnished by the town water-works, and its use is almost universal, the quantity used is so much increased, that it is only a question of time when the earth about cesspools will become saturated with water, and entirely filled with decomposing filth. And this condition will be found, not only on one man's premises, but in entire neighborhoods, growing worse constantly as they become more thickly settled.

The Board would recommend the voters to take action by appointing a committee to consider the question of a sewerage system, with authority to

consult the State Board of Health and obtain their advice and instructions, and with authority to employ a competent civil engineer to make surveys, plans and estimates for a complete system of sewerage, and take any action necessary to make a full report to the town on the subject at some subsequent meeting.

Ipswich.

In regard to the sanitary condition of the town, the people, generally, have complied with the requirements of the Board, and in no case where we have ordered a nuisance abated have we had any trouble or had to resort to legal measures.

In regard to contagious diseases amongst the cattle in the town we will state the following: the selectmen appointed a cattle inspector, and the Board of Health also appointed him as their agent giving him full power to act for them, and he has faithfully attended to his duties. The whole number of cattle inspected by him was eleven hundred and four, and he ordered nineteen of this number quarantined as, in his opinion, they were diseased, and notified this Board of his doings. The State Cattle Commissioners were at once notified in regard to same, who came and examined them and ordered the killing of eight which were sick with tuberculosis, and their carcasses were properly buried.

Lawrence.

Six hundred and seventy-four vaults have been abolished since Jan. 1, 1889. There have been 2,184 water-closets placed in buildings where vaults have been abolished.

During the year 19,714 loads of garbage have been removed, an increase of 4,376 over 1892. Realizing the necessity of a different method of disposing of the waste matter, the Board has recommended that some provision be made to dispose of this material in a satisfactory manner.

There has been an alarming prevalence of scarlet fever during the year, and the percentage of fatalities greater than formerly.

More cases of measles have been reported than ever before, forty-six cases coming in during one week. The fatalities have been small, only three out of sixty cases resulting fatally. Diphtheria has not been very prevalent. During the December vacation, 3,200 school children were vaccinated by the ward physicians. We were pleased at the ready response from the agents of the corporations as we found that vaccination was being carried on in a very systematic manner.

We have had five cases of glanders in horses and seven cases of tuberculosis in cattle, which were pronounced such by the Cattle Commissioners.

Lexington.

The Board has made several official tours of inspection; among them was the inspection of the several hotels and private boarding-houses, and

we are pleased to state that, with few exceptions, the sanitary conditions were good. The inspection of some of the numerous newly built houses was not so assuring; indeed, the systems of house drainage in many of them were alarming. One case, for instance, may be cited: a double tenement; no water supply except from well dangerously near drain; untrapped sinks discharging into an open tank in cellar, contents of which were used to flush closet; without vent; useless trap; cesspool twenty-eight feet from house. It would almost seem that the ingenuity here displayed tended only toward one result, — the death of the occupants.

Some years ago the question of a sewerage system for the town was agitated to the extent of the appointment of a committee, the investigation of different schemes was initiated, and even the engineer's survey obtained. This subject, so vital to the interests of the town, seems to have passed into oblivion; nothing is heard of it except now and then a few desultory remarks on the matter. It is hoped that this subject is not entirely forgotten, for if forgotten and neglected there will be a rude awakening, perhaps within a few years.

Lowell.

During the year 1893, twenty-five thousand five hundred and thirty-seven (25,537) loads of ashes were removed from houses and stores to the various dumping-grounds.

Late in the year 1892, the Engle cremator was completed so that for the year covered by this report it has been in use, destroying about one-half of the garbage of the city. Owing to the usual friction that all new undertakings have to overcome, it was not until April that a complete system of account was commenced. Since April every pound of swill consumed and every pound of coal used has been weighed daily so that, estimating the amount burned the first three months of the year and adding to it the amount weighed for the last nine months, we have, say 3,500 tons of swill consumed for the year 1893, beside the miscellaneous articles enumerated in the table printed herewith: —

Three thousand five hundred tons swill and market refuse burned.
Four horses.
Seventy cats.
Sixty-three dogs.
Two hundred and fifteen mattresses.
Four hens.
Seven rabbits.
One raccoon.
Three loads and one barrel infected clothing (small-pox).
Seven loads infected clothing (diphtheria).
Seventy-seven thousand one hundred and sixteen pounds paper burned on ground in rear of cremator.

The opinion of the Board, after the experience of the year with the Engle cremator is briefly this: Under no circumstances would it be willing to return to the old method of swill-house distribution to farmers, and it is also convinced that cremation of the garbage is more satisfactory to the inhabitants of a city than the rendering process. The cost of burning garbage at Engle cremator, from Jan. 1, 1893 to Dec. 31, 1893, was $7,670.77.

The Board caused a thorough inspection of the water-shed of River Meadow brook to be made, and the results are such as to demand prompt remedial and preventive action.

The work of inspecting the tenement houses of Lowell in a thorough and systematic way has been commenced this year, and so far the results have been very satisfactory; but the great value of the inspection will come in later years, as from the records made and kept by the library system, an inspector can turn to them at any time and find the condition of any house in the city so far as relates to plumbing, drainage and ventilation, and will then only have to keep watch that the premises are kept clean and in repair.

From June 27 to September 16, there were 14,918 baths taken by men and boys, a decrease from 1892 of 8,347, but it is explained by the fact that more than that number used the house to put their clothes in, and then came outside and swam in the river.

Lynn.

The Board of Health appointed an inspector of plumbing under the provisions of chapter 477, Acts of 1893.

Under the provisions of a special act of May 4, 1893, chapter 313 (1893), the Board of Health of Lynn was authorized to appoint an "inspector of provisions, and of animals intended for slaughter or kept for the production of milk, who should also be an inspector of milk, butter, cheese and vinegar."

Each of the officials appointed under these acts contributes a full report of his transactions.

The Board recommends the following amendments to the milk laws: —

1. That the cost of analysis be charged as court costs.
2. That boards of health be vested with power to revoke licenses.

The failure of the city government to carry out our recommendations or to adopt a system for the disposal of garbage and night-soil placed the Board in the predicament, on April 20, of having no place to dump that material, or otherwise dispose of the same by cremation or extraction. To relieve the situation the city purchased the land about the outfall sewer, and we entered into contract with an excavating company and had a temporary basin dredged for the scow on land alongside the outfall sewer at West Lynn. A dock was also constructed with a small, frame building thereon. The disposition of offal by loading it into the scow, towing it

twelve miles out to sea and there dumping it in deep water, was inaugurated, and has proven a success.

Twelve trips have been made and 1,486 tons of offal so disposed of, without accident or a single complaint, at a cost of ninety-four cents per ton for labor, towage and expense of repairs. We shall pursue this method until the city council adopts some other and better one. We recommend the immediate purchase of another scow. The dump at West Lynn was abandoned on the expiration of the lease, April 20, and no garbage was placed thereon after that date.

The Board requested that immediate steps be taken by the city council to provide suitable accommodations for persons affected with contagious diseases.

Marblehead.

The health cart is one of the most important institutions in our town, and we hope has come to stay both summer and winter. Two thousand loads of refuse matter have been collected the past year. To find persons who will look after this refuse and see that it is properly covered has caused the Board considerable trouble. We suggest that the town set aside a place to be used as a dump in case there were no individuals who cared to take it.

We suggest that our town should employ a health officer to investigate nuisances, post notices, inspect meat, milk and water, attend to the fumigating of all places where infection exists, and who would be in many ways of great service and value.

Marlborough.

In parts of our city where the health of our citizens was in danger, and along the banks of brooks, during the past two years, this Board through its agent has enforced connections with the public sewer under the powers granted in the Public Statutes, chapter 132 of the Acts of 1890. The agent of the Board reports that two hundred and sixty-seven buildings have been plumbed; one hundred and fifty-one cases where alterations or additions have been made in the plumbing; making a total of four hundred and eighteen inspected and approved by him. It is evident from the number of inspections made that the people are mindful of the economic and sanitary advantages of the public sewer. The enforcement of our regulations governing plumbing worked to the advantage of all.

Many nuisances that have been a bugbear to every Board of Health for years past have disappeared entirely since the house drainage in these localities has been conducted to the sewer. Cards calling attention to the regulation restraining persons from making the vacant land of the city a nuisance, were posted wherever there seemed to be a cause of complaint.

In August a case of rabies appeared in town. A dog with a disease of doubtful diagnosis was killed by the police. The mayor with a representa-

tive of the Board of Health agreed to request Dr. Ernst of the Harvard Medical School to decide by inoculation experiment whether the disease of the supposed mad dog was actually hydrophobia. The result of the experiments proved that the dog was afflicted with the genuine disease, and proved the wisdom of muzzling all the city dogs. No more cases appeared though several dogs were said to have been bitten by the diseased dog.

Maynard.

The Board has encountered a greater obstacle in trying to educate a certain class of people to understand that it is necessary to flag a house where there is scarlet fever and cause the flag to remain displayed for a proper and legal length of time. They also have seemed to think they were doing the Board a great favor by allowing the flag to be attached to the house at all, and as soon as the case is able to sit up, "although then probably in the most contagious stage," display more or less disposition to resent the idea that it is then highly necessary that the quarantine should remain longer. This condition can only be overcome by education.

Medford.

Sixty-one nuisances have been reported to this Board during the year. All have been carefully investigated and abated.

In each case of diphtheria, measles, scarlet fever and typhoid fever, the clerk has notified the school committee and librarian of the public library.

The work on our local sewage system should be pushed to completion as rapidly as possible, so that we may be rid of that increasing and menacing danger, the saturation of the ground with sewage. Since the collection of ashes, swill and garbage has been under the direct care of the city, and the contract system abolished, the work has been done in a thorough, cleanly and efficient manner, and the results are highly satisfactory to this Board. With the same arguments we have used in the past, in favor of the collection by the city of ashes and swill, we would now earnestly recommend that night-soil be collected in the same manner.

Melrose.

More than one hundred and fifty nuisances and complaints have received attention from the Board. The sources of nuisance or complaint have most frequently been neglected cesspools and offensive privies, but also imperfect traps, or total absence of them, and defective sink drains.

The former method of return to school by children recently recovered from contagious diseases, has been by permits given by the Board, based upon the attending physician's certificate of recovery. But that method having often proved troublesome to parents, a more direct plan is now employed, of permits, based as above, but issued by the chief of police, as

agent of the Board of Health; so that the same officer, who by order of the Board, removes the card, also issues the permit to return to school.

Last spring, in consequence of the threatened invasion of cholera, we instituted a thorough inspection, by a special police officer, of the entire central part of the village. He inspected carefully every yard, and whenever any clearing up was found necessary, he left in the hands of the resident a plainly printed notice, specifying the work to be done, and the time within which it must be done, — usually five days. This course of inspection was faithfully performed, and we believe much good was done by it, often cutting short a nuisance which would soon have become serious. This work of spring inspection has been done now for two years, and the influence has been so salutary, that it may become necessary to establish it as a permanent line of sanitary action.

The passage by the last Legislature of Act 477, "relative to the licensing of plumbers, and the supervision of plumbing," has received the required attention from us. In compliance with section 3 of said act, requiring the Board of Health to appoint the third member of the board of examiners of plumbers, we appointed to that position a gentleman well versed in both the science and practice of house sanitation and plumbing. In accordance with the requirement of section 5, that the Board appoint an inspector of plumbing, we appointed the same gentleman to this office, which is in fact a dependency of the former position.

Milford.

We report but one fatal case of diphtheria, and the circumstances connected with it demand recognition in this report. The physician in attendance could not have recognized the character of the case in its incipient stages, or there was great remissness in reporting it to the Board of Health. He was prosecuted for neglect of professional duty, under the statute. The case was "placed on file." We believe the prosecution was demanded, and will result in much better protection of the town against contagious diseases.

A thorough and free vaccination of the unprotected has been carried out. The Board has vaccinated about eight hundred, and protection according to the statute has been more thorough than ever before.

It may be well again to make mention of the great importance of a system of general sewerage of the town of Milford. Increased population, health and wealth will be the result. Without it, any great progress is impossible.

Millbury.

The cases of diphtheria were very widely separated and, with one exception, away from the densely settled part of the town. The causes were generally not well defined, though in some cases bad house drainage seemed probably responsible. Communication from a previous case was plain in two instances, one case soon following another in the same family.

The cases of scarlet fever were also widely separated as to families affected, and there has not been a general epidemic, all the cases having occurred in but six different houses.

The occurrence of five cases of typhoid fever on one street and within a short radius would seem to imply some local contamination, but no obtainable evidence could satisfactorily explain the origin of the disease. Chemical examination of well waters furnished little light, but since the disease is generally believed to be of bacterial origin, it might well happen that a chemical analysis would give entirely negative results. The milk supply theory did not apply, since there was not a common supply in the different affected families, nor was any disease known on the premises from which the several supplies came. Without attempting to show any connection between the facts, it may be stated that fourteen of the cases were comparatively near the river, eight of them being very near. A very extensive epidemic of measles occurred in the autumn.

It is well for people everywhere to know that it is now believed by the highest medical authorities that consumption is to a very considerable degree communicable from person to person, and that the germs abound in matter expectorated in coughing; that constant care should be taken to disinfect and destroy such discharges, and especially that the common habit of promiscuous spitting should be avoided. Matters so scattered, by drying, become converted into dust, and, in this form, are widely scattered to be inhaled by others, and since the germs are extremely tenacious of life, the seeds of the dire disease are widely sown.

It cannot be doubted that such precautions as are above described would, if generally adopted everywhere, have a marked effect in diminishing the frequency of consumption.

During the year two cases of glanders in horses have been reported to the Board by the inspector of cattle. Both animals were subsequently condemned by the State Cattle Commissioners and killed by their order.

Nantucket.

The Board made investigation of many nuisances reported, and believes that the town has been kept in an improved sanitary condition in consequence of a general interest manifested by all good citizens, to live up to the best ideal of proper sanitary safeguards. As a result of such care and attention, no contagious disease of any kind has been reported to the Board during the year as originating at Nantucket.

Needham.

The health of our town and its freedom from any serious epidemic of infectious and contagious disease (except that of typhoid fever) during the past year is a matter of sincere congratulation.

What will soon be required as the town progresses, to put us in a

thorough sanitary condition, will be a general system of sewerage, which the introduction of a public water supply generally demands.

Your health officer has made one hundred visits of inspection and examination, visiting sixty places where complaints have been made. Fewer petty complaints have been made than in previous years.

Fewer swine have been kept in the thickly settled portions of the town than in former years. Some piggeries have been entirely abandoned. In a few cases, as a last resort, the Board appealed to the court to enforce its orders.

New Bedford.

The Board acting under authority of Public Statute, chapter 80, section 24, vacated houses on Turner's court known as Holy Acre. This act the Board regards as one of the most important taken during the year. The statute places the entire responsibility on the Board. The houses in question were so low that it was impossible to drain them, and it seems unfortunate that there are no means of preventing building or moving houses already built to such locations. In every growing city, building is continually outgrowing the drainage system. But for such buildings drainage can be supplied before they are occupied. The policy of the Board has been and will be to vacate all such tenements at the first sign they give of danger to the public health. The Board would recommend that action be taken on the proposed building rule establishing the height of cellar floors above high water. The nuisance caused by privies is being rapidly abated, when such a nuisance occurs on the line of a sewer.

All garbage is ploughed in daily, and when about one acre is covered a quickly growing crop is planted, and in a surprisingly short time, on digging down, no garbage can be found. Thus the essential condition for rapid decomposition in the earth is attained, namely, superficial burial. The objection to superficial burial is that the burial products may more readily become exposed and so cause nuisance, or, by drying, blow about, and under proper conditions cause disease. This objection is met by the facts that the material buried is not of such a character as frequently contains disease germs, and the moist and heavy condition of the soil is such that it is seldom dry except upon the surface. The farm is remote from any source of water supply. So far the method is satisfactory in all respects. The material is thus utilized as a fertilizer, which is its only value, as the cost of extracting the fat, the only constituent of value, would more than counterbalance the estimated return.

The Board voted to inspect the sanitary condition in respect to drainage of the various school houses in the city. All, with the exception of one, were found in good condition. The school committee were notified of the

The Board investigated an epidemic of typhoid fever which occurred in the last half of the year, embracing 201 cases in all. No satisfactory conclusions were reached which would account for the epidemic as a whole, though suspicion pointed strongly to the existence of infection upon a small island in the harbor which many of the persons attacked had visited during the period of epidemic.

The Board amended its quarantine regulations and publishes them in full in its report.

Newburyport.

There has been a great falling off of cases of diphtheria and scarlet fever from the previous year, but a large increase of cases of typhoid fever.

Rules and regulations relating to plumbing were adopted by the Board.

Newton.

The general health of the city has been good, and barring slight outbreaks of diphtheria in the early spring and fall, and an epidemic of measles in the early summer, would have been deemed excellent.

The contagious wards at the hospital have been found very useful during the year; the early removal of patients to them having greatly aided the Board in preventing the spread of disease. The wards have been in almost continuous use during the year, sixty-two cases having been admitted. The cases were divided as follows, — scarlet fever, fifteen; diphtheria, twenty-eight; measles, nineteen.

The Board authorized free vaccination to all comers in the several villages.

North Andover.

As a matter relating to public health, we think the attention of consumers of milk should be called to the fact that most of the herds supplying milk in this town are not allowed any exercise at all, but are tied up by the neck from November till May in badly ventilated barns, and never turned out of doors.

We recommend the purchase of one of the odorless pumps, and that its use be made compulsory in the village whenever vaults or cesspools are cleaned during the day.

We find occasionally a person who is willing to allow his vault to overflow his neighbor's land. Such need the stimulating effect of the sharp end of the law.

North Attleborough.

The failure of people to submit to the guidance of any fixed rules for observance in trying to prevent the spread of any infectious disease is often due to thoughtlessness rather than to a desire to thwart the beneficial effects of such rules. It often requires the experience of an epidemic to

teach the public that there are certain rules and regulations which must be strictly observed.

There has been a marked decrease in the number of cases of diseases of a contagious character reported during the past year.

Orange.

With the opening of the season the Board recognized the need of removal of "waste, filth and house dirt," and engaged a scavenger who gave two days each week to the collection of rubbish and garbage on the principal streets of the village during the heated season, with the result that never before in the history of Orange was the town in as sanitary a condition.

The Board has investigated one hundred sources of filth and offence. The members, individually, have investigated many others.

The Board of Health would urgently request parents to investigate the subject of "vaccination" thoroughly, that they may intelligently act regarding it.

The bodies of five dead animals have been buried by the Board. Animals infected with tuberculosis have been condemned. Herds have been inspected by the Board's agent. Horses with infectious diseases have been cared for, and dogs killed.

Pittsfield.

The sewage system, now almost completed, has furnished a long-needed want, and the amount of good obtained by the same is immeasurable.

During the year 1893 the new ordinance for plumbing necessitated the licensing of plumbers and drain-layers.

Number of licenses granted to plumbers,	8
" of licenses granted to drain-layers,	13
" of plans of plumbing submitted for approval,	253
" approved,	218
" rejected,	35

During the past year the Board of Health has been called on to investigate four outbreaks of tuberculosis at different farms. At one farm the Board considered about thirty per cent. of the cows affected. So far, twenty-one of them have been slaughtered, and of these nineteen have been found diseased, while two were found not diseased. At another farm over fifty per cent. were considered unsound. Up to date thirteen have been slaughtered, and every one has been found diseased. At another farm two cows have been slaughtered, both of which were affected. The Board considers that the chief cause of its spreading among dairy cows is overcrowding, deficient cubic air space and defective ventilation. The Board also considers a more thorough State system for regulating and managing the disease should be inaugurated.

Plymouth.

Sixty-three places have been examined and nuisances abated without having received any formal complaint.

Nearly all of the cases of scarlet fever, typhoid fever and diphtheria have been traced by the Board to imperfect drainage and ventilation.

After learning the facts in the cases the Board issued orders to those families from which cases were reported, and had them enforced; and the Board felt that after the last case was reported well, and the places had been disinfected, that there would be no danger from these sources. During this time circulars were distributed by the Board throughout the town giving instructions what to do in case of diphtheria.

In accordance with the Acts of 1893, chapter 477, the Board has appointed inspectors of plumbing, and, at the request of the selectmen, prepared a list of by-laws, and presented them to the town for adoption.

Quincy.

Your Board strongly recommends that plumbing regulations or ordinances be enacted by the council as a matter of safety to the public health. The inspector is powerless without them in many cases. The brooks have been thoroughly cleaned under the direction of the inspector, and the Board has every reason to believe that the work has been economically, thoroughly and conscientiously done. The physicians are negligent in their duty of reporting contagious diseases, and until they are brought up to the law the same state of affairs will exist.

Number of nuisances discovered, 306; number abated, 298.

Reading.

There have been twenty-one nuisances investigated, and all cases except two have been abated by owner or occupant. One of these was abated by the Board, and the owner paid the bill. The other one will be attended to before the premises are occupied.

Revere.

The town has been favored with a freedom from contagion to an extent to be a matter of satisfaction to the citizens within the last twelve months. Scarlet fever showed itself the latter part of the year. The prompt and stringent requirements of the Board have done much to prevent it being spread over the town.

Rockland.

We have had one case of glanders reported during the year, and the Cattle Commissioners ordered the horse killed, which was done.

One of the vital questions for the people of this town is that of sewage. While in our present financial condition, any general system for the town

to adopt would be too expensive, yet there is a very simple and effective way of disposing of sewage that could be adopted by individual families. The plan is to have the sewage pass through an underground drain with branches in all directions, the drains to be constructed of broken drain-pipe, stones or anything that will allow the sewage to pass into the ground at short intervals.

Salem.

In the month of February a sharp outbreak of diphtheria occurred near the cotton mills. The type of the disease was very serious and vigorous measures were employed to combat it. Houses were guarded night and day by police officers, thus stopping one of the chief sources for spreading the disease. Everything possible was done for the sick and for the afflicted families.

Though some cases of scarlet fever were severe, only one proved fatal. The type has generally been mild. We note with satisfaction the marked decrease each year for the past three years in the number of cases of this dangerous malady.

The type of typhoid fever was severe and active search for the cause was made by this Board, milk being particularly looked after. Visits to each house were made, also to shops where milk was sold, and the milkmen, their farms, the cattle, the sources of water supply of the cattle. The fault could not be traced to the milk.

The work of collecting the ashes and rubbish the past two months has been done in a very satisfactory manner. Eight thousand one hundred and seventy-two loads have been collected. This is an increase of over 1,400 loads more than in 1892. These ashes have been used to fill up unsightly and often unhealthy places in our city.

Saugus.

The Board made personal investigation of a number of reported nuisances, and on their tour found much work to be done in regard to neglected privies and vaults. These cases were reported to the owners, and in the majority of cases were looked after in a satisfactory manner. Our inspector also found many places where sinks were not secured by traps, which allows of all gases arising from contents of cesspools to flow back into the rooms occupied by the residents. This should not be allowed, and the Board has obliged owners to correct these troubles so far as its knowledge of them is concerned.

Perfect cleanliness of dwellings and surroundings is what will insure good health and is of the utmost importance, as by its strict observance the air is not polluted and germs of disease find no lurking places.

The Board publishes a very full and complete set of regulations including practical instructions relative to disinfection.

Springfield.

There is no unusual epidemic of infectious diseases to be noted in the year 1893. Scarlet fever was more abundant and diphtheria and typhoid fever less abundant than in 1892. The number of deaths from the principal infectious diseases were seventy-six, against one hundred and twenty-one in 1892.

Two cases of small-pox were reported in February and March, one of which proved fatal. The second case was evidently caused by infection from the first, but the source of the original contagion could not be ascertained. There was no further spread of the disease.

This department has been strengthened by the adoption of an ordinance regulating plumbing and by the appointment of an inspector of plumbing. New work must now be done in a proper manner and old work will be gradually improved as is found necessary from time to time until our buildings shall all be properly drained.

Glanders have existed to some extent among horses, eight cases being reported to the State Commissioners and by them condemned, ordered killed, and the premises cared for and made free from contagious infection.

Swampscott.

During the past year we have received and investigated all complaints brought to our notice.

The beaches were cleaned up thoroughly the first of the season; afterwards some person or persons saw fit to dump rubbish thereon, which put us to some extra expense to clean it up again, when they might have carried it to the dump.

Taunton.

The Board severely criticises the sanitary condition of the Central Police Station of the city.

Some time Taunton must have a comprehensive system of sewerage which will do away with Mill River and Cobb Brook and numerous other smaller nuisances. How much of the money spent on small sewers will be a dead loss when the general system is adopted?

The city has been remarkably free from diphtheria and typhoid fever. The scarlet fever epidemic continued through the first half of the year, but since then has gradually abated until the year closes without a single case on the books. An extensive epidemic of measles was experienced in the spring and early summer. The exact number of cases cannot be given. We would recommend that the old ambulance be put into repair and put under control of this Board, to be used in conveying persons sick with contagious diseases.

Wakefield.

We have had no epidemic. The general complaints of nuisances have been few and soon abated, and the more important ones have caused us little trouble. Our formal meetings have been few, but all that were necessary, as the members of the Board met almost daily and the business was often informally discussed and disposed of. We have done nothing toward abating our permanent nuisances this year, as we have concurred with the opinion of past Boards that the expense of the attempted improvement would far outweigh the very doubtful benefit. There is but one way to rid the town of these unsavory and unsightly spots, and that is by a proper sewerage system.

During the session of 1893 the Massachusetts Legislature passed a law governing the business of plumbing in cities and towns in the State. In accordance with this law we appointed a local board of examiners of plumbers.

Waltham.

A request by the Boston Manufacturing Company to remove some cases from corporation tenements compelled the Board to make provision for the treatment and care of scarlet fever patients, and, at first, quarters were engaged in the Newton Cottage Hospital; but the number of cases increased so rapidly that the Board deemed it more convenient and economical to procure a house somewhere in the city for temporary use as a contagious hospital. The result was that the house No. 255 South Street was taken for that purpose, and a house-keeper and a nurse were procured to take charge of cases carried there. This house was maintained as a hospital from March 14 to May 15 and proved ample to accommodate all cases of children sick with scarlet fever whom it was desirable to remove. On one occasion, a mother and child were furnished with board and room while the child was under treatment for the disease. We believe that the prompt removal of cases of scarlet fever to a contagious hospital, well equipped, and managed by the Board of Health, will greatly diminish the danger of the spread of this disease. So positive does the Board feel of this proposition that it thinks it may safely say that a contagious hospital would have prevented all but say twenty cases of the three hundred and eighty reported during the last two years.

Before the schools closed in June the disease was fully eradicated. Since that time cases have only occasionally appeared. During the year, one hundred and thirty-two cases altogether have been reported, as against two hundred and fifty-four cases in 1892.

the public will insist upon the use of as radical measures to prevent its increase as are now employed to prevent the spread of small-pox, and we believe that such measures would go far to stamp it out. In Massachusetts, during the year 1892, there were two deaths from small-pox, while there were nine hundred and twenty-eight from diphtheria. In the whole United States, omitting North Dakota, it is reported that, in the same year, there were only one hundred and six deaths from small-pox. This shows that there were in 1892 only one-ninth as many deaths from small-pox in the United States as there were from diphtheria in the State of Massachusetts alone.

Several cases are detailed in the report, illustrating the value of isolation and removal to a hospital provided for contagious diseases. It is almost needless to say that no effectual isolation can be made in all instances without a contagious hospital to which patients may be promptly removed, and it is as a means by which to effect absolute isolation of these dangerous cases that the hospital now nearly finished will demonstrate its greatest value to the city.

We wish at this point to call attention to a matter which to many may appear trivial, but should not be overlooked by those seeking out the methods by which disease is propagated. Upon a visit of our Board to the public schools we found a custom prevailing in many of them of collecting the children's pencils at night and dealing them out promiscuously the next morning. We believe that this custom is a bad one; and we are pleased to say that, on our suggestion, the superintendent of schools caused a rule to be established that each scholar should have his own individual pencil.

It has long been known that, upon reopening the schools after a vacation, infectious diseases seem to take a fresh impetus, and, on the other hand, when the schools are closed, such diseases seem to relinquish their hold upon the community. We therefore believe that during the long summer vacation, the school houses should not only be cleaned in the usual manner, but also thoroughly fumigated and disinfected from top to bottom, and the basements thoroughly whitewashed.

A contagious hospital is now being built, consisting of two wings and a dwelling-house, all connected by long corridors, one wing being for scarlet fever cases and one for diphtheria cases, each capable of accommodating ten patients; and each is so constructed that it can at any time be enlarged at a comparatively small expense, should occasion require.

Under the plumbing act, as it stands, a board of examiners has been organized, consisting of the present chairman of the Board of Health, the present inspector of buildings, and a practical plumber who was chosen by the Board of Health as the third member.

The Board has adopted a system of registering plumbers who were in business at the time the act took effect, that is, on or before July 10, 1893.

To each plumber registering his name a certificate has been issued certifying that he was engaged in the business prior to that date. These certificates have proved of great practical convenience to the plumbers of the city who do work in other places by enabling them to readily prove the fact that they were engaged in business prior to July 10, 1893, and therefore entitled to pursue their calling without a license.

Altogether about 1,100 connections have been made with the public sewer. The total estimated number of connections made and to be made is 2,500.

Ware.

A careful investigation of the sanitary condition of the buildings and premises in town was made early in the year by agents, who were appointed for the purpose, and who were furnished with printed blanks containing various inquiries, upon which they recorded their answers. At a later time a second visitation was made by these inspectors where it seemed desirable to the Board that it should be done. In this way accurate and complete information was secured as to our sanitary condition.

In compliance with an act of the Legislature passed during the year, the Board prepared a set of by-laws in relation to plumbers and plumbing work, which were adopted by the town, and which are now operative. These by-laws require that those who newly enter the business of plumbing should pass an examination and obtain a license, which must be renewed each year that they continue in business. All plumbing work, except repairs of leaks, must be done only after proper notice given the Board of Health or its appointed agents, and must be approved by the Board after examination by an inspector of plumbing appointed for the purpose.

Wellesley.

No cases of typhoid fever have been reported to the Board during the year.

There have been several instances in which the advice of the Board has been sought in regard to sanitation, and in all cases the suggestions made have been readily complied with.

The Board would respectfully call to mind the fact that householders are required by law, no less than physicians, to report cases of contagious disease occurring within their respective families.

Westborough.

In no instance has the Board been forced to resort to legal measures to secure compliance with its requests.

The general health of the inhabitants of the town has been comparatively good. There has been no epidemic disease, and only four cases of contagious disease dangerous to the public health have been reported.

Westfield.

At the town meeting, held April 8, it was voted: —

That the Board of Health is hereby instructed to compel persons owning, leasing or maintaining any building, to connect with the public sewer, as provided in chapter 132 of the Acts of 1890, on or before the first day of January, 1895.

After mature deliberation your Board decided that the best interests of the public health demanded immediate action, and instructed its clerk to formulate a notice for compulsory entrance. Five hundred of these notices were sent to property owners on the south side of Westfield River. Entrances were made the entire season as rapidly as the property owners could secure attention from the plumbers and drain-layers. Three hundred and fifty-four sewer applications were made, representing the entrance of three hundred and seventy-one buildings, which includes five hundred and eighteen families, besides eight blocks, two churches, one school building, three shops and one stable.

The Board established certain limits in the town, within which the keeping of swine was prohibited, and provided that any and all swine, and any pen or other inclosure in which swine are kept, outside of said districts, shall be kept in a condition of neatness and cleanliness acceptable to the Board of Health.

Westford.

The physicians were prompt in notifying the Board of all infectious or contagious diseases, and where quarantine was established we allowed it to remain until the physician in charge of the case notified us that it was unnecessary. Disagreeable as it was to be shut off from their usual freedom, members of the families where these infectious diseases prevailed readily complied with the regulations, and did much to prevent the spread of the disease. Householders do not seem to understand that the law requires them as well as physicians to notify the Board of Health if they are knowing of infectious or contagious disease within their family or house. The law is very plain, and a heavy penalty is provided for non-compliance with it. But two householders have complied with the law the past year.

Whitman.

The difficulties arising from lack of a sewage system, and the fact that a great deal of the land in Whitman is so low that deep cesspools cannot be dug, have been thoroughly described in preceding reports, and it is hoped that at some future time the desired system may be established. The town has not suffered from many cases of contagious diseases the past year, but all cases which have come to our knowledge have been promptly reported

school committee according to law. When necessary, conspicuous red cards with the name of the disease in large letters have been posted on the premises where an infectious disease was known to exist.

Williamstown.

The Board has attended to the usual matter of nuisances, which have been promptly abated. In connection with board of selectmen, the Board of Health has assisted in the construction of sewers, an excellent advance in this matter, and it is hoped that the same policy will be continued during the coming year.

Winchester.

The Board vaccinated eighty scholars, sixty-one of whom had never been vaccinated before. Some of these had passed through all but the high school.

The Metropolitan sewer is about complete in Winchester, and we hope our local system of sewers will soon be commenced and that, in the near future, Winchester will be supplied with a complete system.

Woburn.

During the year over one hundred complaints were received, concerning existing nuisances, and promptly attended. Among the most prominent was the Pantasote Leather Company nuisance, which had been a cause of complaint for several years, not only by the citizens of our own city, but also by the citizens of the neighboring towns of Reading, Stoneham, Wilmington, Wakefield and Winchester. After a thorough investigation by the Board, they ordered the premises closed until the proper machinery could be introduced to abate the nuisance. The works have not started again, as yet, nor will they be allowed to until all semblance of a nuisance has been abated. A number of complaints were also received from the inspectors of the Boston Water Board and received prompt attention.

Worcester.

Number of complaints for the year ending Dec. 31, 1893, 1,718. Rooms fumigated, 448.

There were three successful prosecutions by the Board during the year, viz., one for keeping pigs without a license, one under the law regulating contagious diseases among domestic animals, one for doing plumbing work without a license.

Twelve houses, containing thirty-five tenements, were vacated on account of bad sanitary condition.

The general sanitary condition of the city through the year was good. There was a slight increase in the number of deaths over the previous year.

Special efforts were made during the summer months to thoroughly clean the city in anticipation of an invasion of cholera, but owing to the effective national quarantine maintained by the general government its entrance was prevented. As usual, a large number of the cases of typhoid fever were due to causes outside of the city. It is probable that several cases were contracted at Chicago while visiting the Fair. We again call attention to the great necessity of a hospital for the care of contagious diseases. The need of such an institution has been, if possible, more forcibly brought to our attention during the year just closed by the appearance of contagious diseases in several of the institutions of our city that are devoted to benevolent and charitable purposes, thereby impairing, if not altogether preventing, their usefulness for the time being.

INDEX.

FIFTH ANNUAL REPORT

OF THE

BOARD

OF

METROPOLITAN SEWERAGE COMMISSIONERS.

JANUARY, 1894.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
18 POST OFFICE SQUARE.
1894.

Commonwealth of Massachusetts.

To the Honorable the Senate and the House of Representatives.

The Board of Metropolitan Sewerage Commissioners, created by chapter 439, Acts of 1889, presents its

FIFTH ANNUAL REPORT.

The past year has witnessed continued and steady progress upon the work entrusted to this Board. On the North Metropolitan system, nine of the thirteen sections reported as under construction in our last report have been completed and contracts have been made for ten new sections, while one section which had been let was in part re-let, the original contractors being directed by this Board to discontinue all work on said section, on account of the same being unnecessarily and unreasonably delayed. Contracts have also been made for a pumping plant for each of the following pumping stations: Deer Island, East Boston and Mystic River, to be delivered and put in place during the year 1894. Work has also been done under the direction of the Board upon the out-fall sewer, extending from the southerly edge of Deer Island, and upon the siphons under Shirley Gut, Chelsea Creek and the Mystic River.

The work of constructing the Charles River Valley system was completed prior to the rendering of our last report. This system has been in steady operation, and numerous connections have been made by the towns and cities thereon. A list of these together with the cost of operation of the system will be found in the tables herewith.

Your attention is respectfully invited to the report of our chief engineer, submitted herewith, and the tables that follow in connection with this report.

NORTH METROPOLITAN SYSTEM.

The condition of work upon this system may be readily ascertained by a comparison of the following tables with the map accompanying our engineer's report. In the first, the sections on this line already completed, with approximate length of each, are shown, and in the second, those sections which are in part completed, and also the length yet to be constructed.

North Metropolitan System (Completed Sections), Sept. 30, 1893.

Section.	Location.	Length of Sections.	Completed.
		Feet.	
Wharf,	Deer Island,	400	Feb. 3, 1891.
2,	Deer Island,	2,146	Dec. 19, 1891.
3,	Deer Island,	2,641	Aug. 8, 1891.
4,	Winthrop,	5,710	June 27, 1891.
5,	Winthrop,	4,600	Dec. 2, 1891.
6,	Winthrop,	4,113.4	Sept. 30, 1891.
8,	East Boston,	4,127.5	June 23, 1892.
9,	East Boston,	3,389	June 24, 1892.
12,	Chelsea,	3,086	Mar. 4, 1893.
14,	Chelsea,	3,448	Aug. 19, 1893.
15,	Chelsea,	1,760	July 20, 1892.
16,	Everett,	4,439.7	May 20, 1893.
17,	Everett,	3,552.5	Feb. 6, 1893.
17½,	Everett,	1,625	Aug. 10, 1892.
20,	Medford,	9,185.6	Aug. 5, 1893.
21,	Medford,	8,035	Sept. 10, 1892.
23,	Everett,	2,271.6	April 29, 1893.
24,	Everett and Charlestown,	2,332	June 2, 1892.
26,	Charlestown and Somerville,	3,748	May 27, 1893.
40,	Everett and Malden,	6,252.7	April 15, 1893.
42,	Melrose and Stoneham,	3,050	June 3, 1893.
43½,	Medford and Somerville,	2,327	Sept. 30, 1893.

Total,	82,190 feet.
Less 400 feet of wharf,	400
	81,798 feet.

Section.	Location.	Approximate Length of Sections.	Completed Sept. 30, 1893.	To be Constructed.
		Feet.	Feet.	Feet.
1, .	Deer Island, ...	1,890	450	1,440
3½, .	Shirley Gut, ...	430	240	190
7, .	Winthrop and East Boston, .	848	575	273
10, .	Between East Boston and Chelsea, ...	712	626	[illegible]
22, .	Medford, ...	6,075	5,078	997
25, .	Mystic River, ...	2,120	425	1,695
27, .	Somerville and Cambridge, .	4,300	3,960	340
28, .	Cambridge, ...	6,500	5,518	982
29, .	Cambridge, ...	5,150	3,115	2,035
30, .	Cambridge, ...	7,020	4,941	2,079
37, .	East Boston, ...	4,900	1,374	3,526
41, .	Malden and Melrose, . .	10,800	10,363	437
43, .	Cambridge and Somerville, .	14,450	10,512	3,938
44, .	Winchester, ...	5,600	3,147	2,453
44½, .	Winchester, ...	5,700	1,395	4,305
45, .	Winchester, ...	6,600	6,164	436
46, .	Winchester and Woburn, .	5,750	4,163	1,587
	Totals, ...	88,845	62,046	26,799

The total length of the sections upon the North Metropolitan system in the above tables is 170,643 feet (32 miles, 1,683 feet). Of this the completed portion amounts to 143,844 feet (27 miles, 1,284 feet), while the portion remaining to be constructed amounts to 26,799 feet (5 miles, 399 feet). The above is entirely independent of and separate from the Charles River Valley system, covering a distance of about eight and one-quarter miles.

The following settlements for land taken upon this system have been made during the year: —

Elizabeth H. Fowler, by deed dated Oct. 27, 1892 (recorded Middlesex South Dist. Reg., book 2154, page 92), conveyed to the Commonwealth the right of way through her land in West Medford, included in the taking made by this Board, dated Nov. 25, 1891; and Margaret Magoun, by deed dated Dec. 19, 1892 (recorded Middlesex South Dist. Reg., book 2164, page 587), conveyed similar rights to the Commonwealth in her land in Medford, included in the

said taking. On Dec. 2, 1892, William Hannan of Malden and Sarah Hannan, his wife, in her right, released to the Commonwealth by deed (recorded Middlesex South Dist. Reg., book 2162, page 136) the right of way in her land in said Malden, included in the taking made by this Board, dated July 23, 1892. Rufus G. F. Candage, on Jan. 7, 1893, by deed (recorded Suffolk Reg., book 2106, page 66) conveyed to the Commonwealth similar rights and privileges in his land lying in Winthrop, included in taking made by this Board on the seventh day of May, 1890; and on June 19 of said year, Samuel C. Lawrence of Medford conveyed to the Commonwealth by deed (recorded Middlesex South Dist. Reg., book 2209, page 203) the right of way across his land on High Street, Medford. Charles E. Jennings, by deed dated Sept. 1, 1893, released to the Commonwealth rights, privileges and easements in and to a certain parcel of land in Everett, included within a taking made by this Board, dated Oct. 29, 1891, "covenanting with the said Commonwealth that I will warrant and defend it against all such lawful claims by me and those claiming under me, or under any assignment from Asa Upham." This deed is accompanied by one from Morris B. Hall of Everett, assigning and transferring to said Jennings "all sums of money now due and coming due to me from the Commonwealth of Massachusetts on account of claim to damages by reason of the taking of land in West Everett, Mass., for the Metropolitan Sewerage, so called." This release is recorded Oct. 13, 1893 (Middlesex South Dist. Reg., book 2226, page 510).

On Sept. 13, 1893, settlement was had by separate deeds with William Richardson and William G. Richardson, both of Winchester, for rights, privileges and easements in and to certain parcels of land in said Winchester, being all the land of said grantors included in the description or taking, signed by the Metropolitan Sewerage Commissioners, dated April 15, 1893. The former deed is recorded in Middlesex South Dist. Reg., book 2229, page 225, and the latter in Middlesex South Dist. Reg., book 2229, page 226. The last two deeds are accompanied by a deed from Orlando M. Brooks of Woburn, administrator of the estate of Samuel Brooks, late of Reading, deceased, the mortgagee named in a certain

mortgage given by William Richardson, dated April 1, 1890, releasing to the said Commonwealth the rights, privileges and easements described in the foregoing deeds, which release is recorded in Middlesex South Dist. Reg., book 2229, page 224.

Henry M. Whitney, by deed dated Sept. 19, 1893, releases to the Commonwealth a certain strip or parcel of land in Everett, "being all the land of said grantor included in the description or taking, signed by the Metropolitan Sewerage Commissioners, dated Aug. 17, 1891." This deed is recorded in Middlesex South Dist. Reg., book 2229, page 228.

On Sept. 22, 1893, Alfred Bailey of Cambridge releases to the Commonwealth rights, privileges and easements in and to a small triangular piece of land in said Cambridge, "being all the land of said grantor included in the description or taking made by the Metropolitan Sewerage Commissioners, dated Feb. 6, 1893" (Middlesex South Dist. Reg., book 2229, page 223).

Land Takings and Purchases.

On the map accompanying our engineer's report of last year, the route of the sewer upon this system was shown, and, with but few exceptions, covered the main or trunk line from Mystic Lake to the outlet at Deer Island, with the Malden and Melrose branch, and considerable of the branch extending south through Somerville and Cambridge. The takings made the past year complete, to a considerable extent, the gaps on the main line, extend the Cambridge branch to its upper terminus, include the branch extending along Alewife Brook, and also the main line extending from Mystic Lake northward through Winchester and Woburn to Stoneham, besides a section of the East Boston branch. In the summer of 1892 a study of the locality convinced the Board that it was desirable to change the course of the siphon under Chelsea Creek, so that it should pass under said creek east of the Chelsea Street bridge. Accordingly, on the eighth day of October, a deed was executed (recorded Suffolk Registry of Deeds, book 2088, page 541) taking in fee simple tracts of land in East Boston and Chelsea for sites for a

nances, together with the right of connecting the same by a sewer passing under Chelsea Creek.

On Feb. 18, 1893, "the right to carry and conduct under the following-described lands and therein to construct, operate and to forever maintain an underground main sewer and connecting sewers, drains, man-holes and underground appurtenances, and to repair and renew the same," was taken, by deed (recorded Suffolk Registry of Deeds, book 2113, page 270), in "all those portions of Chelsea Street, Eagle Square, Prescott Street and Bremen Street, in that portion of said Boston called East Boston, extending from Addison Street and Chelsea bridge to Marion Street." The gap on this system under the Mystic River, between Everett and Charlestown, was taken by this Board on June 24, 1893, by two deeds. One, recorded in Suffolk Registry, book 2141, page 310, takes the right of way through Alford Street and the city of Boston land on the south-easterly side of said street and also in the land under Mystic River, on the south-easterly side of Malden bridge, while the other deed (recorded in Suffolk Registry, book 2142, page 311) takes in fee simple a tract 172 feet by 145 feet on the north-easterly end of said bridge. These takings close the gap existing at the Mystic River, on the map formerly referred to.

The takings on three other sections (28, 29 and 30) on this branch (Cambridge and Somerville) have been made during the year, and cover the land necessary for its construction. Section 28 was taken in two parts, by deeds one dated Nov. 19, 1892 (recorded Middlesex South Dist. Deeds, book 2158, page 574), the other Feb. 6, 1893 (recorded Middlesex South Dist. Deeds, book 2174, page 219). Sections 29 and 30 were taken by deeds, one dated March 25, 1893, and recorded in Middlesex South Dist. Deeds, book 2183, page 245, and the other dated July 19, 1893, and recorded in Middlesex South Dist. Deeds, book 2210, page 481.

The branch designed to relieve the foulness and pollution of Alewife Brook constitutes sections 43 and 43½. The land was taken on Section 43 by two different deeds, the first, dated Dec. 17, 1892 (recorded Middlesex South Dist.

Deeds, book 2165, page 481), covers the spur of this section, extending from the main line to Belmont, and the other deed, dated Jan. 7, 1893 (recorded Middlesex South Dist. Deeds, book 2169, page 457), follows the line of Alewife Brook from Concord Avenue in Cambridge to the neighborhood of the Mystic pumping station in Somerville. Section 43½ was taken May 20, 1893, by deed (recorded Middlesex South Dist. Deeds, book 2197, page 139) and extends from the point last named to the junction with the main sewer at the corner of Canal and Prescott streets in Medford. The remaining takings cover the sections extending from the northern terminus of Section 22 in Medford at the Lower Mystic Lake, through part of Medford, Winchester and Woburn into Stoneham.

On April 15, 1893, the Board took by deed (recorded Middlesex South Dist. Deeds, book 2186, page 585) the land in Winchester, Woburn and Stoneham lying on Section 46; and on the twenty-second day of the same month, by deed (recorded Middlesex South Dist. Deeds, book 2189, page 249), the land in Winchester lying on Section 45. These last two sections cover the line of the sewer from its most northern boundary just inside the line at Stoneham to its point of junction with the Mystic valley sewer.

The Mystic valley sewer and land necessary for a parallel line, together with the purifying works near the Mystic station on the Boston & Lowell Railroad, were taken by two deeds, executed July 14, 1893, and recorded in Middlesex South Dist. Deeds, book 2210, page 161, and book 2210, page 162, — the former taking the land and buildings in Winchester owned by the city of Boston and used as the purifying station of the Mystic valley sewer, and the latter such portions of the Mystic valley sewer itself as were necessary for the completion of this system, together with land sufficient for a parallel line. The city of Boston, who owned this sewer, authorized its transfer to the Commonwealth by the following vote: —

IN BOSTON WATER BOARD, BOSTON, Aug. 23, 1893.

Voted, To release to the Commonwealth of Massachusetts for the sum of fifty-two thousand six hundred and thirty-seven dollars ($52,637) all the right, title and interest which the city of

Boston now has vested in it by virtue of a certain taking, recorded with Middlesex South District Deeds, Aug. 9, 1877, book of partitions, etc., 27, page 491, and by a certain taking recorded with said Deeds, Dec. 13, 1881, book 1586, page 241, or otherwise has in and to any of the land described in either of two certain takings made by the Metropolitan Sewerage Commissioners in behalf of said Commonwealth, both dated July 14, 1893, and recorded with said Deeds, July 18, 1893, or to the buildings or machinery on the premises described therein.

Also, for said consideration, to release and discharge the said Commonwealth, its officers, agents and servants, from all claims, demands, actions and causes of action by it for damages, costs, expenses or compensation by reason of the said two takings by said Metropolitan Sewerage Commissioners, or any lawful acts done under the authority thereof in pursuance of the said takings.

Also, for said consideration, to covenant and agree with the said Commonwealth that it will maintain the sewer and works in the premises above referred to and provide for the disposal of all sewage entering therein as heretofore, until such time as the said Commissioners shall have so far constructed and completed the sewerage system provided for by the plans referred to in chapter 439 of the Acts of 1889, or within the purpose of said act, as to be able to dispose of sewage at the outlet off Deer Island, provided the same shall be constructed on or before July 18, 1895, or otherwise until said day but no longer, and after said July 18 the Commonwealth shall provide for the disposal of such sewage.

And that the chairman of this Board be authorized to countersign an instrument covering the matter above set forth, and as the matter does not admit of delay, that the acting mayor be requested to forthwith execute, acknowledge and deliver such instrument.

A true copy. Attest:

(Signed) W. E. SWAN, *Secretary.*

On Oct. 3, 1893, the mayor of said city and the chairman of the Boston Water Board, by deed recorded in Middlesex South District Deeds, book 2242, page 5, conveyed to the Commonwealth the sewer and works named herein in accordance with said vote. A further taking was made in Winchester, dated Sept. 16, 1893, and recorded in Middlesex South District Deeds, book 2223, page 286, of a small triangular piece of land within the location of the Boston & Lowell Railroad which was not covered by the taking dated July 14, 1893,

but which circumstances had rendered necessary for the construction of the sewer in that locality. On Aug. 19, 1893, the taking of April 22 on Section 45 was modified by changing the course of the sewer in land of the heirs of Samuel Richardson, in accordance with an arrangement made at their request. The said taking is recorded in Middlesex South District Deeds, book 2218, page 117, and was made in lieu of payment of land damage to the owners.

Location of Sewer Line.

Starting on Montvale Avenue in Stoneham, about fifteen feet from the line dividing said town from the city of Woburn, the line crosses said town line and deflects to the south in private lands, following, in general, the course of Clearwater Brook to the neighborhood of the Stoneham Branch of the Boston & Lowell Railroad; thence crossing said railroad it follows the line of a pond and said brook, through private estates, to its junction with Willow Brook, and continues along the northerly side of the latter brook, and the canal leading therefrom, to Washington Street in Winchester. Crossing this street, it follows, through private estates on the line of Willow Brook, to the neighborhood of the watch-hand manufactory, where it crosses said brook and follows its line, through private estates, to Cross Street; passing under the tracks of the southern division of the Boston & Maine Railroad on this street it follows the line of said railroad to a point near the crossing of Willow Brook by said railroad, and thence follows, in general, the line of said brook, through private estates, crossing Swanton Street, to a point within the location of the Woburn Branch of the Boston & Maine Railroad, near Abbajona Pond, Winchester; thence it passes through railroad and private land, parallel with the Mystic valley sewer, to Main Street, thence through Main and Common streets to the Winchester station, where it again enters private estates, and crossing to the east side of the railroad, continues to a point about three hundred feet south of Mystic station. Here the railroad is crossed again, and the line is continued through private estates to a point in the old Middlesex Canal, opposite the precipitation works of the city of Boston, and then follows

the canal to the terminus of Section 22, near the Lower Mystic Lake. This line measures 23,545 feet, of which 2,710 are in public highways and 20,835 in private land.

The branch extending south for the relief of Alewife Brook and that neighborhood leaves the trunk line at the junction of Canal and Prescott streets, in Medford, follows the former street and crosses private estates to the Mystic River. Crossing the river and a private estate, it follows Boston Avenue and a private way to Jerome Street, near the Mystic pumping station; and then, passing through land of the city of Boston and sundry private parties, follows the general line of Alewife Brook to Concord Avenue in Cambridge. A branch of this line starts near the junction of the Massachusetts Central with the Lexington and Arlington Branch Railroad, and follows the general line of the former road, through private lands, across the town line into Belmont. These sections measure 17,030 feet in length, 1,155 of which are in public highways and 15,875 in private lands.

The line of the Cambridge, Somerville and Charlestown branch was described in our last annual report from its junction with the main sewer in Everett to the corner of Portland and Bristol streets in Cambridge. From this point it passes through Portland and Albany streets, across Front Street, Cambridge, thence through private lands to Waverly Street and through Waverly Street to its junction with Henry Street. Here it passes through private land, crosses Brookline Street and other private land, crosses Pearl, Granite and Magazine streets, and continues through private estates to River Street, and thence via Blackstone, Albro and a proposed street to Western Avenue. From the latter point private lands are crossed to DeWolf Street. This street and Dyke Street are followed to other private lands, which are crossed, to Boylston Street, and thence crossing Boylston Street the line continues via Eliot Street, Eliot Square and Mt. Auburn Street, and terminates on the latter street at its junction with Lowell Street. These three sections measure 18,660 feet, 6,820 of which lie in private lands and 11,840 in public highways.

By the taking made Oct. 8, 1892, the line of the sewer

between East Boston and Chelsea was changed so that as now laid out it extends from the terminus of Section 12 on Marginal Street in Chelsea, across flats bordering on the bridge and Eastern Avenue, under Chelsea Creek, to the neighborhood of the crossing of Addison Street by the Grand Junction Railroad in East Boston. From here it continues through Chelsea Street, Eagle Square, Prescott Street and Bremen Street to its junction with Marion Street. The length of this line, including the siphon under Chelsea Creek, is 5,760 feet, 5,140 of which lie in public highways and 620 in private land, the latter including the river and flats adjacent thereto.

The following correspondence passed between this Board and the War Department at Washington, D. C., in relation to the construction of work in contact with tide-water, and the same plans have received the approval of the Board of Harbor and Land Commissioners of this State: —

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSION, 110 BOYLSTON STREET,
BOSTON, April 8, 1893.

To the Honorable DANIEL S. LAMONT, *Secretary of War of the United States of America.*

Respectfully represents the Board of Metropolitan Sewerage Commissioners of Massachusetts that your Department approved, April 9, 1891, various constructions pertaining to the Metropolitan sewerage system, and, among others, a siphon under Shirley Gut, between Winthrop and Deer Island, which siphon was shown on Tracing No. 830 (submitted on March 21, 1891) as composed of three lines of sixty-inch pipe. This Board now desires to have the siphon consist of a single pipe with an inside diameter of six feet two inches and an outside diameter of eight feet five inches (which proposed change was approved by the Massachusetts Board of Harbor and Land Commissioners on April 5, 1893), as shown on Tracing No. 1560, submitted herewith. This modification places the *upper* surface of the pipe at the same depth as in former plan. The position of the pipe in plan as now proposed is the same as the middle pipe formerly proposed.

Mr. Howard A. Carson, our chief engineer, is at your service to furnish any further information you may desire.

Wherefore this Board respectfully requests that the said work, as last above described, may be authorized, approved and permitted. (Signed) HOSEA KINGMAN,
Chairman Metropolitan Sewerage Commissioners.

OFFICE OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY,
WASHINGTON, D. C, April 24, 1893.

Mr. HOSEA KINGMAN, *Chairman Metropolitan Sewerage Commissioners, 110 Boylston Street, Boston, Massachusetts.*

SIR: — Referring to your letter of the 8th instant, submitting to the Secretary of War, with request for approval, a drawing showing proposed modification of the plan approved by the War Department April 9, 1891, for a siphon under Shirley Gut, between Winthrop and Deer Island, I have to advise you that the Secretary of War has approved this modified plan under date of the 21st instant. By direction of the Chief of Engineers,

Very respectfully, your obedient servant,
(Signed) H. M. ADAMS, *Major, Corps of Engineers.*

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSION, 110 BOYLSTON STREET,
BOSTON, May 27, 1893.

To the Honorable DANIEL S. LAMONT, *Secretary of War of the United States of America.*

Respectfully represents the Board of Metropolitan Sewerage Commissioners, ordered by chapter 439 of the Acts of 1889 of the General Court of said Commonwealth to construct the Metropolitan sewerage system; that your department approved April 9, 1891, various constructions in Boston harbor pertaining to this system, and, among others, an outfall from the southerly end of Deer Island, which outfall was shown on Tracing No. 829 (submitted March 21, 1891). The said tracing showed the outfall to consist of three lines of four-foot pipe. This Board now desires to have the outfall consist of one line of pipe with an inside diameter of six feet two inches and an outside diameter of about nine feet (Method A); or of two lines of pipe each having an internal diameter of five feet and an outside diameter of about five feet four inches (Method B); or consisting partly of construction by Method A and partly by Method B, as the difficulties met with in actual work shall dictate; all as shown on Tracing No. 1621, submitted herewith. The centre line and upper surface of the construction as now proposed (either Method A or B) differs but slightly from that formerly proposed. Mr. Howard A. Carson, our chief engineer, is at your service to furnish any further information you may desire.

Wherefore this Board respectfully requests that the said changed construction, as above described, may be authorized, approved and permitted. (Signed) HOSEA KINGMAN,
Chairman Metropolitan Sewerage Commissioners.

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSION,
110 BOYLSTON STREET, BOSTON, May 27, 1893.

To the Honorable DANIEL S. LAMONT, *Secretary of War of the United States of America.*

Respectfully represents the Board of Metropolitan Sewerage Commissioners, ordered by chapter 439 of the Acts of 1889 of the General Court of said Commonwealth to construct the Metropolitan Sewerage System, that your department approved April 9, 1891, various constructions in Boston harbor, pertaining to this system, and, among others, a siphon under Mystic River at Malden bridge, which siphon was shown on Tracing No. 851 (submitted March 21, 1891). The said tracing showed the siphon to consist of two lines of four-foot pipe. This Board now desires to have the siphon consist of one line of pipe with an inside diameter of five feet and an outside diameter of about seven feet, the pipe to be laid to a depth not less than shown by the upper profile if construction is done by tunnelling, or to a depth not less than shown by the lower profile if construction is done by dredging, or it may be necessary to do part by tunnelling and part by dredging, as the difficulties met with in actual work shall dictate; all as shown on Tracing No. 1598, submitted herewith.

Mr. Howard A. Carson, our chief engineer, is at your service to furnish any further information you may desire.

Wherefore this Board respectfully requests that the said changed construction, as above described, may be authorized, approved and permitted.

(Signed) HOSEA KINGMAN,
Chairman Metropolitan Sewerage Commissioners.

The plans for construction at the out-fall at Deer Island, and also for the siphon under Mystic River at Malden Bridge as amended, were both duly approved by the War Department and work is in progress thereon.

CONTRACTS.

Contracts for the construction of ten new sections have been made on this line during the past year and one section under contract was in part re-let, as previously stated. The methods of advertising, receiving bids and awarding contracts have been fully described in our previous reports

and were followed in these particular cases. Oct. 22, 1892, was the date for receiving bids on Section 28, Cambridge, when the number received was twelve, as shown in Table A, Appendix, and the contract was awarded to John L. Reardon & Co., the lowest bidders. On Oct. 12, 1892, the following communication was laid before the Board: —

COMMONWEALTH OF MASSACHUSETTS.

CHIEF ENGINEER'S OFFICE, METROPOLITAN SEWERAGE COMMISSION,
ROOM 5, 93 LINCOLN STREET, BOSTON, Oct. 10, 1892.

Messrs. HOSEA KINGMAN, TILLY HAYNES, HARVEY N. COLLISON, *Metropolitan Sewerage Commissioners*, Boston, Mass.

GENTLEMEN: — I have frequently reported to you the slow progress of the sewer and the various mishaps which have occurred on Poplar Street, Section 27, McGovern & Kitch, contractors. The said contractors, however, have until now been making fair progress on Portland Street, and their progress, taking both working sections together, has been such that I did not think it best to make to you the formal certificate of complaint required by article L, page 41 of the contract. To-day, however, the work on Portland Street was stopped, and I am told that the men were paid off and discharged. Little or no progress has been made on the Poplar Street working section for ten days or more. I know of no valid reason for their delaying the work, especially that on Portland Street, and I hereby certify that, in my opinion, the said work is unnecessarily and unreasonably delayed. I make this certificate so that if you desire you can take some action at your meeting on Wednesday, but I recommend that no action be taken until Friday or Saturday, for the reason that contractor Kitch is away and is expected to return on Thursday, and contractor McGovern states that he is unable to say what he shall do until said Kitch returns. I have arranged to pump out the stagnant water in the trench, which caused a nuisance.

Yours respectfully,
(Signed) H. A. CARSON, *Chief Engineer.*

The clerk was thereupon directed to notify said contractors to appear before this Board on Saturday, Oct. 15, 1892, in accordance with which the following communication was sent: —

BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS OF MASSACHUSETTS,
93 LINCOLN STREET, BOSTON, Oct. 12, 1892.

Messrs. McGOVERN & KITCH, Hotel Warren, Somerville, Mass.

GENTLEMEN: — Will you meet the Board on Saturday next, (Oct. 15, 1892) at eleven o'clock, prepared to decide whether you will abandon your contract or not, and, also, whether the work called for by said contract shall be taken and completed by the Board at your expense, under the terms and conditions of Section L, page 41, of said contract, or not?

For the Board,
(Signed) EDWARD P. FISK, *Clerk.*

The said contractors failed to appear as notified and the following communication was submitted to the Board by the chief engineer: —

COMMONWEALTH OF MASSACHUSETTS.

METROPOLITAN SEWERAGE COMMISSION, CHIEF ENGINEER'S OFFICE,
ROOM 5, 93 LINCOLN STREET, BOSTON, Oct. 15, 1892.

Messrs. HOSEA KINGMAN, TILLY HAYNES, HARVEY N. COLLISON, *Metropolitan Sewerage Commissioners*, Boston, Mass.

GENTLEMEN: — I hereby certify that in my opinion the work on Section 27, McGovern & Kitch, contractors, is unnecessarily and unreasonably delayed.

Yours respectfully,
(Signed) H. A. CARSON, *Chief Engineer.*

Thereupon, the following votes were passed by the Board: —

Voted, That McGovern & Kitch, the contractors for work on Section 27, be notified to discontinue all work under their contract for work on said section; that work on said section be immediately prosecuted by the Board, under the direction of the engineer, in accordance with provisions of Section L of their contract.

Voted, That the surety on bond be also notified of notice to the contractors.

In accordance with the above votes, the contractors were notified of the action of the Board, one copy being sent to them by mail and another being delivered by messenger at their residence in Somerville; and a communication was sent to the Boston office of the American Surety Company of New York, the surety on said contractors' bond, notify-

ing said company of the Board's action. The Board thereupon advertised for bids for the construction of that portion of this section from station 17 in Medford Street, near the Fitchburg Railroad, Somerville; through Medford, Warren and Portland streets to the end of the section at station 47 plus 50, near Bristol Street, Cambridge, a distance of about 3,050 feet. The bids were received and opened on Nov. 5, 1892, when the Metropolitan Construction Company, the lowest of seven bidders, received the award and duly executed the contracts.

One week later, on Nov. 12, 1892, fourteen bids were received for the construction of Section 43, following the general line of Alewife Brook from a point near the Mystic Pumping Station in Somerville to Concord Avenue, Cambridge; with branches at Broadway, Somerville; at the Middlesex Central Railroad; and from the extension of Spruce Street, Cambridge, extending nearly parallel with the Massachusetts Central Railroad to the Belmont town line; a total distance (including branches) of about 14,450 feet. This section was awarded to the lowest bidder (Metropolitan Construction Company) and contracts therefor were duly executed. No other bids were opened until February, 1893.

On the 11th of that month seven bids were received for the construction of Section 37, lying in Chelsea Street, East Boston, from a point near Addison Street through said street and Prescott and Bremen streets to Brooks Street. John Sheehan, the lowest bidder, received the award and executed contracts.

Bids for building Section 46, covering the line of this system at its extreme north, were received and opened on Feb. 25, 1893, when from ten bids that of Charles Linehan, the lowest bidder, was accepted, and the contracts duly executed by him.

One month later bids on Section 29, Cambridge, and Section 45, Winchester, were received, seven on the former and ten on the latter. After a full consideration, the contract on Section 29 was awarded to Lindsay & Cudmore, the lowest bidders, and that on Section 45 to Everson & Liddle, and contracts were duly executed by these parties. (Lind-

say & Cudmore, the lowest bidders on this latter section, having been awarded the contract on Section 29, requested that they be permitted to withdraw their bid on Section 45; this permission was granted and the contract was awarded to Everson & Liddle.)

The portion of sewer following the general course of Alewife Brook, extending from the neighborhood of the Mystic Pumping Station in Somerville to the junction of this branch with the main sewer at the corner of Prescott and Canal streets in Medford, was opened to bidders May 13, 1893, when, from three bids, that of the Metropolitan Construction Company, the lowest, was accepted, and the contracts in due time were executed.

On June 3, 1893, bids were received for constructing Section 30 in Cambridge and Section 44 in Winchester. Three bids were received on Section 30 and two on Section 44, and both sections were awarded to Jones & Meehan, the lowest bidders in each case, who duly executed contracts with the Commonwealth.

On the 19th of August bids were received on Section 44½, extending from the terminus of Section 22 at Mystic Lake, parallel with the Mystic Valley sewer, to the neighborhood of the Winchester station. Nine bids were received, and Weaving, Booth & Co., the lowest bidders, were awarded the contract and executed the same.

Contracts for Pumping Plant.

Contracts have been made the past year for the pumping plant for the stations on this system at the Mystic River (Charlestown), Chelsea Creek (East Boston), and at Deer Island. The bids for the two latter stations were received May 27, 1893, and for the former on July 1, 1893. Ten competitors presented plans and bids for the station at East Boston and nine for that at Deer Island, while only three contended for that at Mystic River, Charlestown. The bid of the Edward P. Allis Company, the lowest bidder in each case, was accepted and contracts executed. Full particulars of these bids and of all bids received by the Board are given in the Appendix herewith.

Expenditures.

The expenditures upon this system, including all payments on account of contracts during the twelve months ending Sept. 30, 1893, amount to $1, 172,269.02. This, with the amount previously reported, $1,662,257.10, makes the total expenditures to date $2,834,526.12. Your attention is called to the tables submitted herewith for matters of detail.

Charles River Valley System.

This system was completed prior to the rendering of our last annual report, and beyond the settlement of land damage with sundry parties and its steady operation, there is but little to report. Table D in the Appendix contains a full statement of the cost of operation for the year ending Sept. 30, 1893, and the following settlements have been made for land damage: on Oct. 20, 1892, Henry M. and Sarah M. L. Bates, by deed recorded with Middlesex South District Deeds, book 2155, page 161, released to the Commonwealth land of theirs in Newton, taken by this Board, by deed dated March 7, 1891. On Dec. 20, 1892, a release was given to the Commonwealth by Sarah T. Hewes, which is recorded with Middlesex South District Deeds, book 2167, page 273, of rights, privileges and easements in land lying partly in Newton and partly in Watertown. Emily A. and William C. Parker, by deed dated Jan. 6, 1893, conveyed to the Commonwealth rights, privileges and easements in and to land in that part of Newton called Newtonville, which deed is recorded in Middlesex South District Deeds, book 2170, page 388, and is accompanied by a release to the Commonwealth from the Newton Savings Bank, the mortgagee, recorded in Middlesex South District Deeds, book 2170, pages 385 and 386. John C. Chaffin, by deed dated Jan. 12, 1893, conveyed similar rights in land of his at Newtonville, said deed being recorded in Middlesex South District Deeds, book 2170, page 386. Joseph W. Pearson and Hannah E., his wife, in her own right, conveyed by deed dated Jan. 28, 1893, and recorded in Middlesex South District Deeds, book 2177, page 81, rights, privileges and easements

in land in Newton, and Jonathan W. Bemis, by deed dated March 1, 1893, recorded in Middlesex South District Deeds, book 2177, page 226, released to the Commonwealth rights, privileges and easements in his land in Newton, included in the description or taking made by this Board, recorded March 24, 1891, in the above registry. The latter deed is accompanied by a release from Theophilus Frye, a lessor of part of this estate, to the Commonwealth of all claims, demands, actions and causes of actions whatsoever arising from the construction, operation and maintenance of the sewer. Clarence W. Jones, trustee for Annie L. Jackson, and the said Annie L. Jackson, by deed dated March 6, 1893, released to the Commonwealth rights, privileges and easements in and to a certain parcel of land in Watertown, their deed being recorded in Middlesex South District Deeds, book 2182, page 316.

The Butchers' Slaughtering and Melting Association, by W. F. Warren, treasurer, duly authorized by vote of the stockholders, conveyed to the Commonwealth by deed (recorded, Suffolk Registry, book 2152, page 241) certain rights, privileges and easements in a portion of a certain estate on Western Avenue, Brighton, known as the Charles River Hotel estate, included in the taking made by this Board March 7, 1891, said portion containing the sewer, with land sufficient for its operation. In part compensation, this Board released to said Association all that portion of this estate included within the said taking, and not described in said deed. Parties upon this line, with whom no agreement as to the amount of damages sustained were made, have brought actions against the Commonwealth, claiming that they are injured by the taking of their respective estates and property, and the same are now pending in the Superior Court in Suffolk and Middlesex counties as follows: —

Suffolk County. — Frederick Ayer, land in Boston adjoining Back Bay Fens; Francis W. Lawrence *et al.*, trustees, land partly in Boston and partly in Brookline (St. Mary's Street); Francis W. Lawrence, St. Mary's Street; George Wheatland, Jr., St. Mary's Street; Boston & Albany Railroad Company, land corner of Essex Street and Commonwealth Avenue, Boston; Eben D.

Jordan (Beacon Park), Brighton; Butchers' Slaughtering and Melting Association, Brighton; John E. Cassidy, Brighton.

Middlesex County. — Boston & Albany Railroad Company, part of location, Newton; John E. Cassidy, Newton; Walter U. Lawson, Newton; George F. Livermore, Newton; Albert Brackett, Newton.

The claims of the National Construction Company for additional compensation for the construction of Sections C and D, and that of Jones & Meehan for similar claims on Sections E, F and G, have been settled and releases given by these parties to the Commonwealth, the former bearing date of July 5, 1893, and the latter the date of July 31, 1893.

The towns and cities embraced within this system, in addition to the connections stated in our last annual report, have made, in accordance with plans approved by this Board, connections with the Metropolitan sewer as per accompanying table: —

Connections made with the Metropolitan Sewer in the Charles River Valley from Sept. 30, 1892, to Sept. 30, 1893.

Date.	City or Town.	Location of Connection.	Size.
1892.			
-	Boston, . . .	Huntington Avenue and Parker Street, .	15 inch.
Oct. 8, .	Newton, . . .	Near Cheesecake Brook, ...	24 inch.
Oct. 18, .	Boston, . . .	Commonwealth Avenue and St. Mary's Street.	18 inch.
Oct. 28, .	Boston (Brighton), .	Western Avenue near Everett Street, .	24 inch.
1893.			
Jan. 27, .	Boston (Brighton), .	Near Salt Creek, ...	24 inch.
Feb. 3, .	Boston, . . .	Vila Street, ...	24 inch.
May 2, .	Boston (Brighton), .	Near Parsons' Brook, ...	24 inch.
May 11, .	Newton, . . .	California and Said streets, . . .	10 inch.
May 12, .	Boston, . . .	Park Commissioners' Administration Building.	6 inch.
May 26, .	Watertown, . .	Barker's Starch Factory, ...	6 inch.
July 1, .	Boston (Brighton), .	Near Faneuil Station, ...	15 inch.
Aug. 25, .	Boston (Brighton), .	Rena and Bertram streets, ...	15 inch.
Sept. 1, .	Newton, . . .	California and Dalby streets, . . .	10 inch.
Sept. 26, .	Boston (Brighton), .	The Abattoir, ...	15 inch.

These, with the connections reported in our last annual report, show twenty-seven connections made with the Metropolitan sewer by the towns and cities embraced within this system, which are distributed as follows: Boston, six; Brookline, one; Boston (Brighton), nine; Watertown, four; Newton, six; Waltham, one.

The expenditures upon this system, including all payments on account of contracts during the twelve months ending Sept. 30, 1893, but not including expenses of operation which are particularly stated in Table D of the Appendix, amount to $28,882.27. This, with the amount previously reported, $679,787.03, makes $708,669.30 as the total expenditures to date.

Your attention is called to tables submitted herewith for matter of detail.

During the year $12,783.61 has been expended that is chargeable to both systems in general, which amount, added to that formerly reported, $15,997.21, makes $28,780.82 so spent to this date. The expenditures of this Board to date may be stated concisely thus: —

North Metropolitan system,	$2,834,526 12
Charles River Valley system,	708,669 30
Both systems,	28,780 82
	$3,571,976 24
Engineering, administrative and contingent expenses,	126,804 16
Total expenditures to date,	$3,698,780 40

GENERAL — BOTH SYSTEMS.

The year passed witnessed a catastrophe which at first appeared likely to cripple the work of the Board. The records of Friday, March 10, 1893, read as follows and tell the story concisely: "About 4.30 o'clock this P.M., fire broke out in the Ames Building, 93 Lincoln Street, and before it could be controlled consumed said building with others in that neighborhood. Beyond the contents of the safes in the offices, the property belonging to the Commonwealth was destroyed. The lives of none of the employees of the Board were lost in the fire, all escaping."

REPORT OF THE CHIEF ENGINEER.

When the safes were opened the books, papers and documents therein were found to be water-soaked, but most of them were, when dried, legible and were made presentable by re-binding. An invoice book and letter book which were in use at the time of the fire were destroyed. Two statement books, classifying expenditures, the one by localities and the other by the month, and a journal and ledger, were so much damaged that they could no longer be used. The Board then immediately proceeded to look for new quarters and engaged rooms in the Walker Building, 110 Boylston Street, for one year, with the privilege of terminating the lease August 31, by thirty days' notice, or upon the last day of any month subsequent. The annual rental is $3,050, payable in equal instalments upon the first day of each month.

The annual meeting of the Board was held, as provided by the act, on the first Monday of February (February 6), 1893, and Hosea Kingman of Bridgewater, who had been reappointed by the Governor and confirmed by the Council, was chosen chairman, and Edward P. Fisk of Boston, clerk.

The Appendix contains tables showing in detail the receipts and expenditures for the year; also the assets and liabilities at date.

HOSEA KINGMAN,
TILLY HAYNES,
HARVEY N. COLLISON,
Metropolitan Sewerage Commissioners.

BOSTON, Oct. 1, 1893.

REPORT OF THE CHIEF ENGINEER.

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REPORT OF THE CHIEF ENGINEER.

BOSTON, Sept. 30, 1893.

HOSEA KINGMAN, TILLY HAYNES, HARVEY N. COLLISON, *Metropolitan Sewerage Commissioners.*

GENTLEMEN: — The work of construction on the North Metropolitan Sewerage System began in May, 1890, three and one-third years ago. Since that time the work has been continuously prosecuted, even the winter months showing some progress. Work on the Charles River Valley System, for the towns of Waltham, Watertown, Newton, Brighton, Brookline and part of Boston proper, was begun in June, 1890. The system was completed in the winter of 1891–92, and has been in operation ever since. Detailed accounts of the work on both systems up to one year ago have been given in the preceding annual reports. The parts completed at this date (September 30), the parts in process of construction and the parts yet to be entered upon can be most readily seen by an examination of the annexed map. The portions remaining to be done and on which work is now in progress (indicated by dotted red lines on the map), are: About one thousand four hundred linear feet of outlet south of Deer Island, gaps on the siphons (Shirley Gut, Belle Isle Inlet and Charlestown) and on the sand-catcher at Chelsea Creek, with parts of contract sewer sections 22, 27, 28, 29, 30, 37, 41, 43, 44, 44½, 45 and 46; and the three pumping stations (one each at Deer Island, East Boston and Charlestown), the plant for which has been contracted for and the foundations for which will soon be begun. The following work has not been entered upon (indicated by the yellow lines on the map): Sections 11, 31, 32, 35, 38, 39 and 47, and gap on 43½, which are wholly on branches, and the siphon at Malden River.

ASSISTANT ENGINEERS, CLERKS, ETC.

I subjoin a list of the names, and principal duties rendered, of most of those who have assisted me during the past year. The number is greater than in any preceding year. This is partly on account of more extended construction work, and partly on account of the fire of March 10, which, as stated elsewhere, destroyed

many of our plans, instruments, models and sketches. In a short time the progress of the work towards completion will render unnecessary the further services of a considerable number of these gentlemen. I desire to here express, both to those who are soon to go and to those who are to remain for a longer time, my high appreciation of their valuable services.

Office Assistants.

CHARLES H. SWAN, *Assistant Engineer:* Studies of grades, elevations and sizes of sewers, positions of branches, designs for structures, etc.

SIDNEY SMITH, *Assistant Engineer:* Plotting of the Charles River Record Plans. Surveys for Sections 31, 32, 35, 43, 43½.

WINSLOW BLANCHARD, *Assistant Engineer:* Studies regarding pumping engines, Shirley Gut siphon and smaller structures.

ALFRED N. WAHLBERG, *Draughtsman:* Laying out and plotting contract plans on various sections, including studies for connections, etc.; making land-taking plans.

WILLIAM W. LEWIS, *Assistant Engineer:* Studies and draughting on pumping engines, Shirley Gut and Malden River siphons and outfall sewer.

PAUL S. YENDELL, *Draughtsman:* Plotting contract and land-taking plans, special structures, etc.

FRANK M. SHERMAN, *Assistant Engineer:* Making and plotting Surveys in East Boston and Winchester.

HENRY CLEARY, *Draughtsman:* Plotting, making and lettering contract and record plans.

FRANK J. NOWELL, *Draughtsman and Photographer:* Making plans, photographing, etc.

ALFRED F. BRIDGMAN, *Assistant Engineer:* In charge of office records; purchasing supplies and making miscellaneous calculations regarding the work.

ARTHUR B. CARTER, *Clerk and Stenographer:* Stenographic work; classification of land and other claims and collecting data for reports.

WILLIAM GRAY, *Clerk:* Examining and checking estimates, bills and pay-rolls.

BURTON W. TORREY, *Clerk.*

ALFRED W. TREFRY, Indexing and caring for plans.

FRANK T. DANIELS, *Temporary Draughtsman:* Work at Deer Island.

ALFRED STEBBINS, JR., *Temporary Draughtsman:* Plans and tracings, Shirley Gut siphon.

FRANK A. EMERY, *Temporary Draughtsman and Transitman:* Making and plotting surveys, Charlestown.

DAVID H. WINSLOW, *Temporary Draughtsman:* Copying land-taking plans at registry of deeds to replace those lost by fire.

AMBROSE H. WHITE, *Temporary Assistant:* Surveys in Charlestown.

JOHN H. GREGORY, *Temporary Assistant:* Plotting surveys in Charlestown.

NELSON A. HALLETT, in charge of testing cement.

GEORGE J. REICHENBACHER, testing cement.

Field Assistants.

Assistant Engineers in general charge of field engineering as stated:

WILLIAM M. BROWN, Jr.: Sewer sections, except the outlet and those in close connection with siphons and pumping stations mentioned below.

LAURENCE BRADFORD: Outlet sewer at Deer Island, siphon and sewer connections at Shirley Gut, pumping station foundations at Deer Island.

H. H. MARDEN, Jr.: Siphon and sand-catcher, Belle Isle Inlet, and the sewers connected therewith; sand-catcher and siphon at Chelsea Creek and connecting sewers; day work on section 12; Charlestown siphon under Mystic River; foundations of pumping station at East Boston.

Assistant Engineer Fred V. Fuller (until his resignation early in March to accept another position) had general charge of giving lines and grades and making estimates and record plans on sewer sections 12 (contract work), 14, 16, 17, 23, 40 and 43.

The other assistants employed in the field are mentioned in the detailed account of the sections which follows and which is in the main condensed from reports received from the assistant engineers on the work.

DETAILED ACCOUNT OF THE SECTIONS.

Ground water from underdrains has been usually controlled by drainage pumps operated at rectangular wells from six to eight feet square at the surface, located against the sheeting at one side of the sewer trench. The sewer has been heavily reinforced with concrete in the vicinity of such wells.

To prevent the movement of ground waters along the sewer, cut-off walls have been built at intervals of about one thousand feet. In the smaller trenches these have been about two feet thick, and in the deeper and wider trenches from three to four feet in thickness, usually of Rosendale and sometimes of Portland concrete. They have entirely surrounded the sewer and extended from one foot below the underdrain, which they cut off, to the ordinary height of the ground water, say from three to six feet below the surface, and in width to from one to two feet outside the lines of the trench. To insure contact between the earth and concrete, all timber from the trench has been taken out about the cut-offs.

The diameters of the sewers hereinafter given are those named in the contracts. In actual construction they have frequently been slightly enlarged for various reasons.

The cost data in each instance is the cost to the Commonwealth.

Section 1 (Day Work), Outlet Deer Island.

Location. — From a point about 60 feet inside of high water line, on the south-westerly shore of the Island, following the westerly side of Deer Island Spit to a point about opposite the Deer Island Spit light.

Length of section, about . . . . 1,950 feet.

Diameters of sewer 6 feet 2 inches.

Assistants.

Superintendent: Charles G. Craib.

Foreman: B. L. Sykes.

Transitmen: Principal — Frank E. Winsor.

" Assistants — Nathan B. Wilber, George A. Winsor, Daniel J. Sullivan.

Trench.

Length completed, ...	526.00 feet.
Average depth of excavation to bottom of underdrain, ...	14.00 "
Greatest depth of excavation to bottom of underdrain, ...	20.00 "
Average width top of trench, ...	11.67 "
Average width bottom of trench	10.00 "

Cubic yards excavation per linear foot, 5.60.

Approximate cost of trench to date per linear foot, including coffer-dam, sheeting left in, excavation and refilling below masonry, backfilling, etc., $44.00.

Character of Earth Excavation. — Sand and gravel, with a little clay in some places at the bottom.

Masonry.

Diameters of underdrain laid and length of each size: —

Six-inch, ...	10 feet.
Eight-inch, ...	16 "
Fifteen-inch, ...	500 "

Approximate cost of masonry to date per linear foot of trench, including underdrain, etc., $20.00.

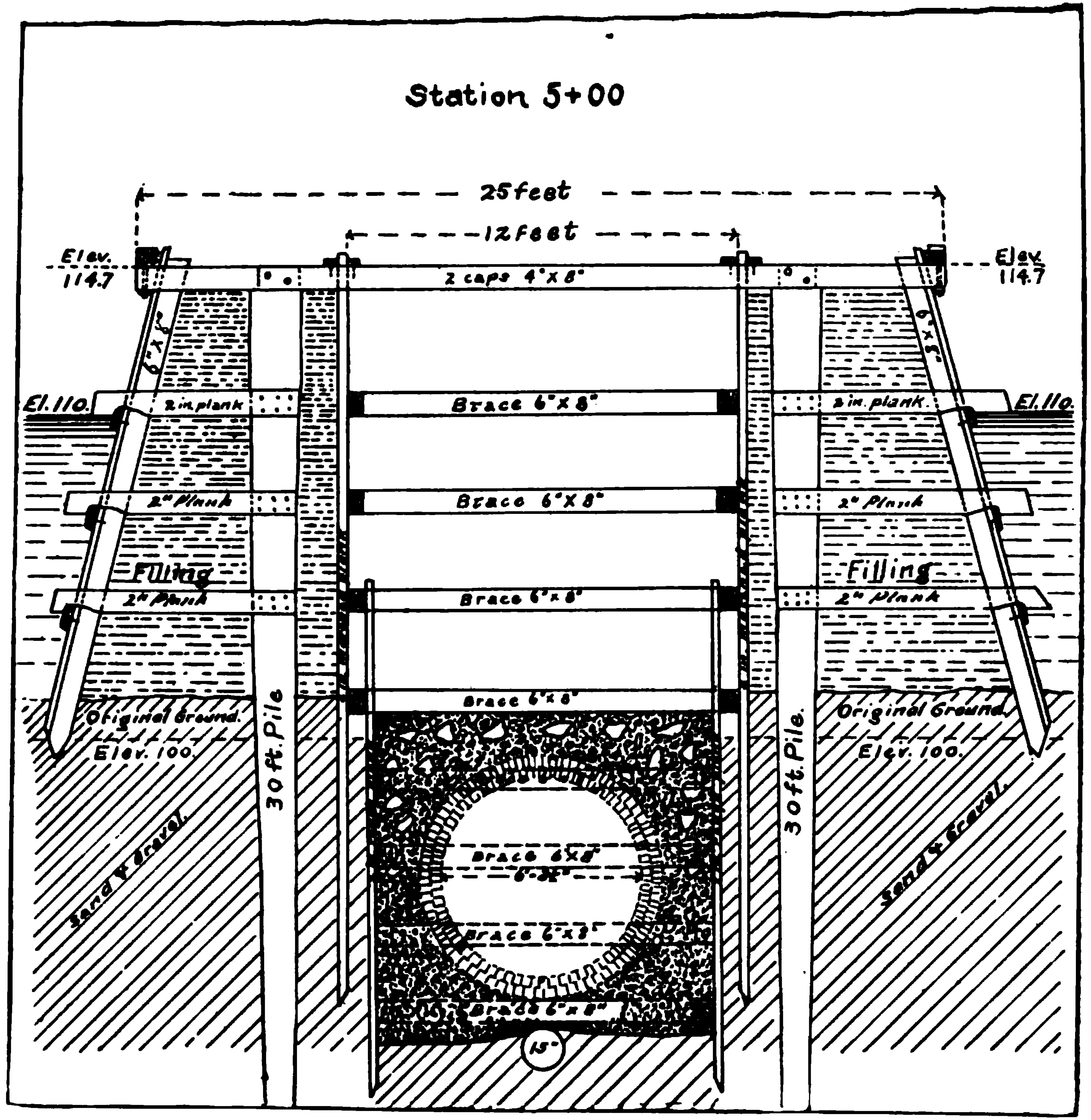
Length completed, ... 450 "

Masonry begun, June 28, 1893, and is now (September 30) in progress.

Approximate cost of section to date per linear foot of excavation and masonry, including labor, material and inspection, coffer-dam, and miscellaneous items, $70.00

Coffer-Dam. — The surface of the ground for the first hundred feet of the sewer for this section is above high water. The remainder of the surface is from five to ten feet below high water, which has necessitated building a coffer-dam at the sides and outer end of the trench as the work progressed. The cross-section of the trench is shown in an adjacent cut.

The excavated trench material of sand and gravel has been used for filling in the coffer-dam, but as there has not been enough of this, and for the further reason that it is too porous to be used alone, a quantity of suitable material has been brought from the site of the pumping station. The round pile bents are six feet apart on centres and are capped across the trench, the top of the bents being at elevation 114.7. The last hundred feet of piling



Section 1, Outfall Sewer, Deer Island. Coffer-dam and Cross Section of Sewer.
November 16, 1893.

Section 1, Outfall Sewer, Deer Island. Coffer-dam and Machinery. September 29, 1898.

has been spur-shored. For a distance of about three hundred and thirty-six feet beyond high-water line two-inch sheeting was used, and four-inch the rest of the way.

Excavation. — Work was begun about the middle of June, 1893, at the shore end of the section. The method of operation is by a travelling derrick, with buckets for excavating from the trench into dump cars. The dump cars are emptied at the coffer-dam at the sides and end of the trench. The trench has now been excavated to grade for a distance of five hundred and forty feet. The ordinary progress per week has been about thirty-three feet. A nine-inch centrifugal pump was put in near the brick sewer built at the beginning of Section 2, soon after the work of excavation was begun, and was operated continuously. On August 6 a six-inch centrifugal pump was put in about two hundred and eighty feet beyond this first one, and on September 15 a second one of these latter pumps was put in the same well. The water handled has been the leakage from the sea, varying with the tides. The greatest amount pumped per twenty-four hours has been about 1,100,000 gallons. A pump well and platform has been started about five hundred feet beyond the high-water line.

Foundation. — The concrete surrounding the brick masonry rests on the mixed gravel and sand found in the bottom of the trench above an under stratum of clay.

Miscellaneous. — The arch of the sewer consists of eight-inch brick-work covered by concrete up to the level of the bed of the sea. Boulders of the size of paving stones and larger are imbedded in the upper surface of the concrete.

Section 3½ (Day Work), Siphon Shirley Gut.

Location.— From the end of the sewer already built (end of Section 3), on the northerly end of Deer Island, underneath Shirley Gut to the sewer already built (beginning of Section 4) on the southerly end of Point Shirley, Winthrop.

Length of section, about	430 feet.
Character of structures: —	
9 foot brick sewer on Deer Island side and gate-chamber, length, .	84 "
Four sections pipe (⅜ inch riveted tank steel shell, lining of three rings brick-work; inside diameter of shell, 8 feet 5 inches; inside diameter of brick-work, 6 feet 2 inches): —	
One curved middle section (75 feet radius), length of arc, .	61 "
Two curved side sections (165 feet radius), length of arc, each,	68 "
One straight end section, length, ...	48 "
Two man-holes (straight lengths at either end with a man-hole going above high water, to be cut down and stopped on completion of work), length, each, ...	12 "
Sand-catcher (about 16 feet by 16 feet) and branch, length, about .	54 "
Six feet two inches circular brick sewer, length, about . . .	27 "

State Assistants.

Foreman: Charles G. Craib.

Engineering Clerk: Frederick D. Smith.

Transitmen: Principal — Frank E. Winsor.

" Assistants — Nathan B. Wilber, George A. Winsor, Benjamin F. Sullivan.

Inspector of Dredging: Daniel J. Sullivan.

Principal Furnishers of Material or Labor.

Pile driving: Josiah Shaw.

Pipe Shell: James Russell Boiler Works Co.

Putting lined pipe on rolls and moving to low-water mark: John Cavanagh & Son.

Dredging trench: Perkins & White.

Diving (making joints, inspecting bottom, etc.): Hiram W. Phillips, John Stone, W. D. Duncan.

Bulkhead.

Length completed: —	
Cribwork and embankment,	226.00 feet.
Pile bulkhead,	239.00 "
Maximum height, about	27.50 "
Elevation of top of capping,	112.70 "
Approximate cost of length completed, including material, labor, etc.: —	
Cribwork and embankment,	$1,973 00
Pile bulkhead,	6,233 00

Work begun, May 25, 1893; finished, July 19, 1893.

Dredged Trench.

Location. — Sixty-five feet westerly from bulkhead and parallel to it, across the Gut.

Length completed,	264.00 feet.
Length partly dug and which refilled during two storms latter part of August,	48.50 "
Average depth of completed trench, natural bed of Gut to bottom of excavation,	14.00 "
Greatest depth of completed trench, natural bed of Gut to bottom of excavation,	20.00 "
Average width top of completed trench,	60.00 "
Average width bottom of completed trench,	10.00 "
Depth of bottom of completed trench below mean high water: —	
Deer Island end,	18.00 "
Centre,	37.00 "
Point Shirley end,	17.00 "

Total approximate cost of dredged trench to date, $4,564.

Dredging for trench proper begun July 17, 1893; finished Aug. 15, 1893.

Character of Earth Excavation. — Sand, gravel and boulders.

Pipe.

Length laid (distance between points on surface),	240 feet.
Weight of pipe sections in air: —	
Central pipe,	225,000 lbs.
Curved pipe, Point Shirley side,	250,000 "
Curved pipe, Deer Island side,	250,000 "
Straight pipe, Deer Island side,	176,000 "
Approximate cost to date of pipe laid, including lining with masonry, material, labor, moving to low water, sinking, connecting, etc.,	$21,210 00

Dates of launching, floating out into position and setting: —

Central pipe,	September 14.
Curved pipe, Point Shirley side,	" 23.
Curved pipe, Deer Island side,	" 26.
Straight pipe, Deer Island side,	" 27.

Approximate cost of whole section to date (September 30), including bulkhead, dredging, pipe and miscellaneous items, ... $33,000 00

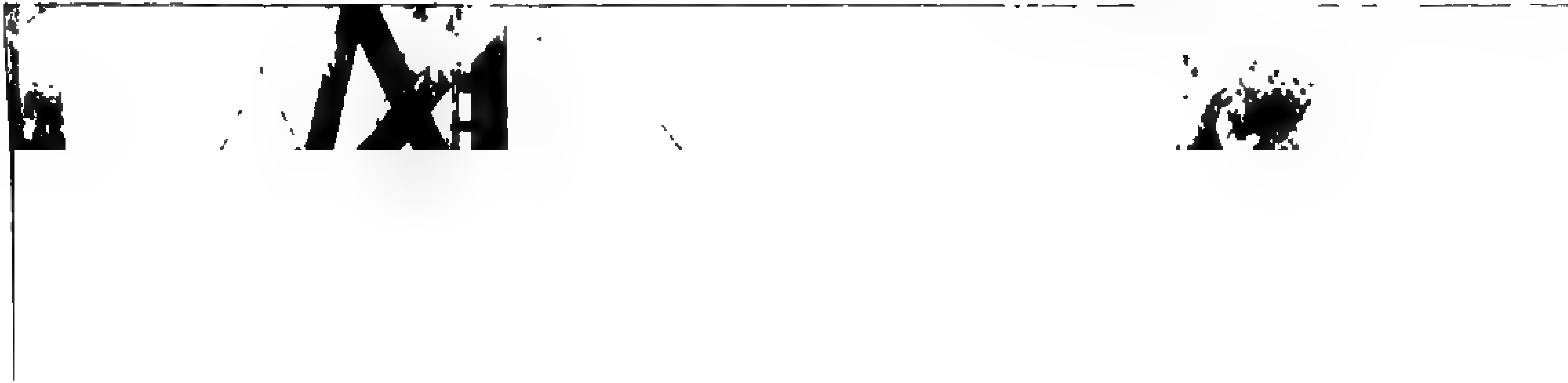
Shirley Gut is a narrow strait separating Deer Island from Winthrop. At the point selected for the sewer it is 315 feet wide at mean high water, and at low water has a width of 105 feet. The very swift tidal current at this point practically never ceases. The depth of water at mean high tide in the middle of the Gut is about twenty-five feet. It was necessary that the sewer passing under the Gut (connecting the sewer already laid on the Deer Island side with that on the Winthrop side) should be in the shape of a depressed loop or siphon having its axis in the middle of the channel way about twenty-two feet lower than the axis of the sewer on the Winthrop side. This was necessary to secure safe construction, and in order also not to impair navigation, and it involved digging a trench from twelve to twenty feet below the bed of the Gut. On account of the uncertainties and risks involved it was concluded that the work be done directly under the supervision of the engineering department, instead of contracting for it as a whole. It was decided to lay a single line of sewer, such as described in the tabular statement above. The use of the steel shell was simply for strength and tightness in the process of laying. It is not necessary for the steel shell to prove permanent.

A branch is provided on each side, so that if experience in the actual maintenance and operation shows it to be desirable an additional line can be laid across in the future when found to be necessary.

The first step in the work was to build the above-mentioned bulkhead to stop the tidal current. This permitted a dredge to operate in still water to excavate the necessary trench, and protected the trench long enough for the operation of laying the pipe. The steel pipes, in sections of 48 to 68 feet, as noted in the table already given, were placed near high-water mark on the Winthrop shore. They were lined with brick, and bulkheads were constructed at the end of each section. These bulkheads were eight inches thick, of hard pine timber, and were caulked by ship caulkers, and as a further precaution they were covered with sheets of rubber, which were cemented to the steel outer shells of the sections. The bulkheads were strongly secured to the masonry of the pipes. To test the tightness of these pipes an attempt was

made to exhaust the air from the interior of them by means of steam ejectors. It was at first found that the partial vacuum, as indicated by the vacuum gauge, was only about one inch of mercury. The rubber sheets were then taken from the ends of the pipe and the ends covered with Portland cement mortar. This mortar, after it was set, was painted with asphalt, and various joints of the steel shell were examined and leaks found and stopped and the sections made practically tight. On the afternoon ebb tide of September 13 and the morning ebb tide of September 14 the middle section was moved on rollers to low-water mark by building movers. In the meantime, the dredging scow, 33 feet 8 inches wide, 79 feet long, 6 feet 6 inches deep, had been fitted with two overhanging trestles or sheers, with specially made blocks and tackle for hoisting, holding and lowering the pipe. These sheers were placed on the side of the dredge about 35 feet 8 inches apart, and so arranged that they could be later moved to other appropriate distances for handling the other sections. About 12:30 P. M. on September 14, the tide then lacking about one hour from high water, the dredge was anchored to the southward and the hoisting tackle was attached to two steel rope straps which were wound around the sections (in grooves in wooden lagging), about fourteen feet from each end. The four drums of the two hoisting engines were then slowly set winding. In this manner the pipe was lifted and pulled from the twelve-inch square timbers and eighty six-inch diameter hard-wood rollers on which it rested. They immediately rose to the surface, covering the vicinity with floating wood. The dredge and the pipe were then pulled out to deeper water, and the pipe lowered a few inches. It was found that the weight of the pipes in salt water was just about that calculated, and the pipes when lowered sank nearly, but not quite, to submersion. The scow and pipe were then moved so that the latter was nearly over the position which it was finally to occupy. As will be seen by the adjacent drawing, the pipe was bow-shaped. When moved from the shore to near its final position its symmetrical plane was horizontal. This plane had now to be revolved ninety degrees, so that it would become vertical with the concave lines of the pipe uppermost. This was done by hoisting on two ends of the straps and lowering on the other two ends. After letting some water into the pipe through a small gate provided for that purpose, and increasing its weight with a few sand bags, it was lowered to its final position, and rested on two cross-sills which had previously been accurately set in the bottom. Its true position in plan as it was lowered was determined by vertical wires which were stretched from points on the middle

Section 3½, Shirley Gut. SIPHON SECTIONS SHOWING END BULKHEADS AND WOODEN LAGGING, WITH GROOVE FOR WIRE ROPE STRAP.
August 19, 1893.



Section 8½. Middle Section of Shirley Cut Siphon, after turning and before lowering. September 14, 1893.

Section 34. Moving the Winthrop End Section of Shirley Gut Siphon down the Beach. September 22, 1893.

Section 34. Launching the Deer Island Man-hole Section of Siphon. October 17, 1893.

plane of the pipe to pulleys on the hoisting rig. Its descent to its true position in plan was facilitated and partly brought about by two ropes, one at each end of the pipe. These ropes, passing under pulleys in the bottom of the Gut (in the exact central line of the sewer), ascended to the top, were led to the scow, and were kept in tension by six or eight men to each rope. The pipes had exterior flanges at their joints, with forty holes at each joint large enough for one-inch diameter bolts. Between these flanges were placed rubber gaskets three-quarters of an inch in thickness and three and one-half inches wide. The pipes were bolted together by divers. Concentric attachments called fingers were placed on the lower parts of each end of the pipes so that the adjoining end of the next pipe laid would of necessity occupy very nearly its true position as to line and grade. Many other details were provided to compel each pipe, though out of sight, to go precisely to its proper place and to give evidence above the surface that this was being accomplished. All these devices resulted in reducing the work under water to the lowest practicable terms. Each flanged joint was finally surrounded by a small box, and this box was filled with Portland cement grout. Later these joints were covered over with clay brought in scows. Work remains to be done (September 30), in connection with the pipes, as follows: Refilling trench, removing Shirley Gut bulkhead, placing temporary manholes, taking out pipe bulkheads, and making masonry lining continuous. The depth of the backfilling will nowhere be less than three feet, and will generally be from five to six feet.

The various assistants and foremen connected with the Shirley Gut siphon undertaking took great interest in thinking out and discussing with the writer the necessary details, and the success achieved was largely due to their intelligent work. The latter statement is applicable to the work on other portions of the Metropolitan system.

SECTION 7, WINTHROP AND EAST BOSTON.

Location. — From a point about 300 feet westerly from Pleasant Street Station, on the Boston, Winthrop and Shore Railroad, across Belle Isle Inlet and Marsh Island to a point on the marsh in East Boston about 100 feet easterly from Riverside Avenue.

Length of section,	848 feet.
Diameters of sewers and length of each size: —	
Main sewer, horse-shoe shape, 8 feet 6 inches by 9 feet 2 inches,	516 "
Sand catcher, horse-shoe shape, 16 feet by 16 feet 5 inches,	84 "
Siphon (three parallel lines sewer, each 5 feet diameter), and approaches (pipe chamber, reducer chamber), etc.	248 "

Contractors. — Trumbull & Ryan of Boston, Mass.

Contractors' Superintendent and Principal Foreman (Year ending Sept. 30, 1893), Charles E. Trumbull.

State Assistants (Year ending Sept. 30, 1893).

Inspector: R. H. Sumner.
Transitmen: Principals — E. Elbert Young, Charles L. Weeks.
" Assistants — Wm. H. Boardman, Jr.; Charles Kincaid.

Trench.

	Main Sewer.	Sand Catcher and Siphon Approaches.	Siphon.
Length completed, feet,	510.00	130.00	73.00
Average depth of excavation to bottom of trench, feet,*	6.48	12.38	13.60
Greatest depth of excavation to bottom of trench, feet,*	14.00	15.00	14.00
Average width top of trench, feet,	17.20	30.30	22.67
Average width bottom of trench, feet,	17.06	31.10	20.33
Volume of excavation per linear foot, cubic yards,	4.00	15.92	10.06

* The depths given in the above table are measured from the bottom of Belle Isle Inlet. The bottom of the trench at its greatest depth is about nineteen feet below low water.

Approximate cost of trench to date (September 30) per linear foot, including coffer-dam, sheeting left in, excavation and refilling below masonry, backfilling, etc., may be distributed as follows: —

Main sewer,	$30 00
Sand catcher,	49 00
Drop to siphon,	80 00
Siphon,	78 00

Character of Trench Excavation. — Sewer proper: river mud, fibrous peat and soft clay. Siphon: sand so fine that 92 per cent. went through a sieve having 2,500 meshes to the square inch, and 4 per cent. went through a sieve having 22,500 meshes to the square inch.

Masonry.

Contract price: —

Brick-work, per cubic yard (brick and cement furnished by the Board),	$5 00
Concrete, per cubic yard (gravel and cement furnished by the Board),	2 50
Squared-stone, per cubic yard (stone and cement furnished by the Board),	3 50

Diameters of underdrain laid, and length of each size: —

6-inch (in some places two lines),	467 feet.
10-inch,	233 "

Approximate cost of masonry to date (September 30) per linear foot may be distributed as follows: —

Main sewer,	$22 00
Sand catcher and overflow,	77 00
Siphon,	34 00
Drop to Siphon and Gate-chamber,	150 00

Lengths of masonry completed: —

Main sewer,	372 feet.
Sand catcher and drop to siphon,	130 "
Siphon,	74 "

Masonry was begun, July 28, 1892; and is now (September 30) in progress.

Approximate cost of section to date (September 30) per linear foot of trench and masonry, including labor; underdrain, foundation piles, lumber and other inspection, and material; miscellaneous items, may be distributed as follows: —

Main sewer,	$58 00
Sand catcher,	156 00
Siphon,	130 00
Drop to Siphon and Gate-chamber,	270 00

NOTE. — The information regarding Section 7 following this note, relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation, Foundation, etc. — The plant for the work has consisted of two steam derricks, one hand derrick, one hand pile-driver, one floating pile-driver, two six-inch and two four-inch centrifugal pumps, six hundred feet of track, six cars of two cubic yards capacity each. The derricks have been used for excavation and for laying stone masonry. Operations have been carried on from each side of the inlet, continuing from last year's work. On the west side, excavation has been for a gate-chamber and incline to siphon, and seventy-three feet of siphon trench, a total length of about one hundred and seventeen feet. The average progress per week on the siphon trench was about three feet. One hundred and twenty feet of trench has been dug on the Winthrop side since August 7, the progress averaging about twenty-three feet per week. Pumping has been done directly from the portion of the trench where work has been going on by means of two six-inch centrifugal pumps and one of four-inch. During the time of the greatest pumping activity it is estimated that water was pumped from the siphon trench at the rate per twenty-four hours as follows: High tide, 2,160,000 gallons; low tide, 720,000 gallons. The maximum amount of water pumped in twenty-four hours from the main sewer trench was about 120,000 gallons. From Jan. 19 to March 19, 1893, work was shut down on account of the exposed location and severe weather. The material in the bottom while not exactly quicksand, still presented many of the same difficulties in the handling. The coffer-dam put in by the contractor consisted of four lines of sheet piling secured and guided by waling pieces fastened to round piles. These round piles were driven by the floating pile-driver. A photograph showing the general arrangement of the coffer-dam was given in the report of last year. Sheeting was driven across the trench at intervals of about forty feet, and excavation was done in the shafts thus formed. The fineness of the sand forming the bed of the inlet was such that it gave great resistance to penetration by sheet piling. After the plank had been driven about five feet into the sand, the blow from a hammer, 2,200 pounds weight, falling twenty feet, would cause a penetration

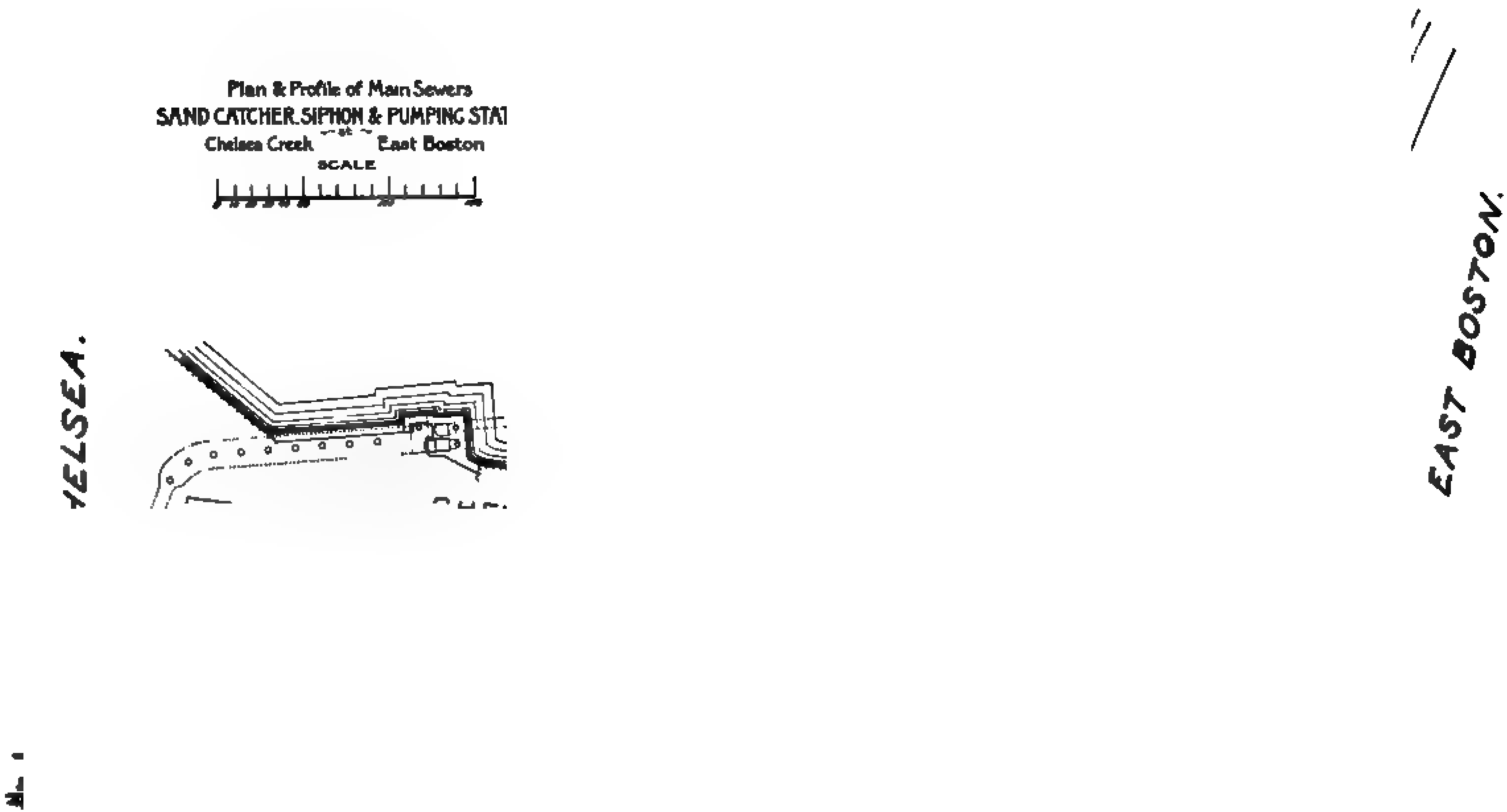
of one-quarter of an inch. Planks taken from the cross bulkhead were frequently broomed for four feet of their lower lengths. Planks were also found sound at the bottom and top but broomed and offset in the middle, or distorted in other ways. Apparently the sand packed so tight around the bottom of the plank that the resistance to penetration became greater than the strength of the timber. The effect of the hard driving was seen as trench excavation progressed. Some planks projected into the trench and some out. The grooves were opened in a majority of cases. At high tide sand and water came in through these cracks freely. The method of overcoming the trouble was to nail boards over the cracks as rapidly as possible. From October 13 to September 18 there were twenty-one occasions when this inflow was not stopped before the trench was flooded. Each of these inflows usually caused delay of greater or less length, from a few hours to thirty-three days, but usually only for a day or so. The last four floodings which occurred (all in the same place) were due apparently to the sheeting of the coffer-dam being deflected by a sunken hulk. After each flood the space between the inner and outer sheeting was filled with clay or mixed clay and gravel, enough being put in each time to stop the leaks sufficiently to allow the pumps to empty the trench. This operation was repeated for each flooding. Foundation piles for supporting the main sewer on the Winthrop side of the Inlet, the incline to the siphon and the gate-chamber, have been driven for a length of one hundred and twenty-five feet. The piles for the western half of the main sewer have been driven six piles in a bent, and for the rest five piles in a bent, — the bents being four feet apart and the average length of the piles below cap being about twenty-nine feet. The platform is of four-inch spruce. There are twelve piles in the bents for the westerly gate-chamber and incline to the siphon, with caps of spruce twelve inches square. The bents are four feet apart, and the average length of the piles is about twenty-nine feet.

Miscellaneous. — The concrete used in the siphon was mixed in the proportions of one part of cement, two parts of sand, three parts of crushed brick.

SECTION 10 (DAY WORK), EAST BOSTON AND CHELSEA.

Location. — From the site of the proposed pumping station at East Boston, near the Grand Junction Railroad bridge over Chelsea Creek, thence under Chelsea Creek between the Grand Junction Railroad bridge and the Chelsea Street road bridge, to a point on Marginal Street near Eastern Avenue, in Chelsea, where connection is made with Section 12.

Length of section, ... 709 feet.


Plan & Profile of Main Sewers
SAND CATCHER, SIPHON & PUMPING STAT
Chelsea Creek ~ at ~ East Boston
SCALE
YELSEA.
EAST BOSTON.

Character of Structures: —	Length.
Siphon (Tunnel) 5 feet 8 inches,	504 feet.
Gate-chamber and Overflow (gate well, 16 feet by 29 feet by 7 feet; overflow opening, 5 feet by 10 feet),	38 "
Sand catcher, 15 feet 5 inches by 16 feet 1 inch,	145 "
Reducer (from sand catcher to main sewer),	10 "
Main sewer, 8 feet 4 inches by 9 feet 2 inches,	12 "

Assistants.

Superintendent of tunnel construction: Charles A. Haskin.
Foremen: tunnel work — Henry Hertz, John Duffy, Patrick McCarthy, P. Fitzgerald.
Foreman: trench work — Charles P. Horton.
Transitmen: Principals — E. Elbert Young, Charles L. Weeks.
" Assistants — Wm. H. Boardman, Jr.; Joseph J. Comfrey.
Draughtsman: F. M. Wilbar, Percy E. Gifford.

Tunnel for Siphon.

Tunnel Excavation.

Length completed,	504.00 feet.
Average depth below level of ground at shaft (El. 115), to bottom of excavation,	52.90 "
Greatest depth of excavation measured to bottom of sump at shaft,	58.20 "
Average width of excavation,	8.00 "

Cubic yards excavation per linear foot, 2.

Approximate cost of excavation to date (September 30) per linear foot, including proportion of shafts, $50.00.

Approximate Character of Excavation in Tunnel. — For about 160 feet from site of proposed East Boston pumping station, hard-pan; for next 90 feet or so, clay with some boulders; for about 45 feet, gravel and clay; for about 100 feet, mainly clay, with a little silt; for about 30 feet, black sand; for about 50 feet, clean sand; for balance of distance, the sewer tunnel rested on sand, with silt above.

Tunnel Masonry.

Approximate volume of brick-work, Portland cement mortar, per linear foot, where used,	1.00 cub. yd.
Approximate volume of concrete, Portland cement mortar, per linear foot, where used,	1.33 " "
Approximate cost per linear foot: —	
Brick masonry,	$21 00
Concrete masonry,	16 00
Length completed: —	
Brick masonry,	442 feet.
Concrete masonry,	57 "

Masonry begun, Nov. 15, 1892; finished, May 4, 1893.

Approximate cost of tunnel per linear foot of excavation and masonry, including proportion of shafts,	$70 00

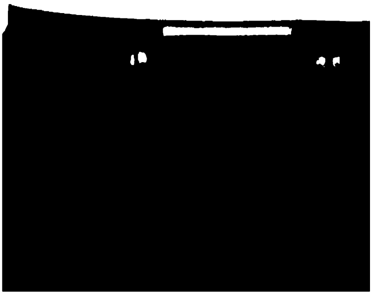
Plant.

One incline.

Tunnel cars.	Capacity at 90 revolutions.
One Ingersoll air compressor, 16 inches by 24 inches,	350 cubic feet per minute.
One Ingersoll air compressor, 18 inches by 20 inches,	375 cubic feet per minute.

Three upright boilers, 45 inches by 9 feet.
One Lidgerwood hoister, 6 inches by 8 inches.
Elevator and appliances.
One 4-inch centrifugal pump.
One No. 5 pulsometer.
One 8 inches by 14 inches by 12 inches Blake pump.

Account of Construction. — As stated in the report of last year, ground was broken at Shaft No. 1 Sept. 26, 1892. This shaft was located between the track of the Grand Junction railroad and the river wall of Chelsea Creek, one hundred feet from the lower end of the section. An incline was used in digging this shaft, as was also the case in the other shaft to be mentioned later. The location of the shaft rendered the sinking very difficult. The small space between the railroad and the river made it impossible to get far enough away to have a natural dam of earth between the shaft and the creek. The retaining wall which forms the bank of the creek in this neighborhood allowed a free channel for water from a distance, and made it impracticable to build an earthen dam by filling outside the shaft. On this account, after the shaft had been commenced, 22 feet by 24 feet, and carried down 15 feet through the river wall, into what appeared to be sound impervious material, it was continued of the size of 13 feet by 14 feet, and tongued and grooved plank were extended from this point to the surface. The space between the planks forming the smaller size and the sheeting of the original size was filled with fine sand. The earth at the depth of 18 feet was coarse and admitted water freely, making it necessary to work by tides. To shut off the water from the porous streaks, grout made of neat cement was poured behind the sheeting, and in places where stones, etc., did not admit of the excavation being true to the lines of the sheeting the spaces were filled with rich concrete. The shaft was not down to grade until November 9. In the beginning of the digging at this shaft a four-inch centrifugal pump was used. When the lift became too great for this a five-inch pulsometer was used. In driving the tunnel the material was loaded in cars at the heading and run to the shaft. The cars were hoisted to the surface by the cage, run on a horizontal track elevated seven feet above the surface of the ground and dumped into carts. From this Shaft No. 1 two headings were worked; the southerly about eighty feet, where it met the heading from Shaft No. 3; the northerly heading about 404 feet, where connection is made with the gate chamber. November 10 excavation in the north heading commenced, and November 15 masonry was commenced. On November 19 excavation in the south heading was begun, followed by masonry two days later. November 27, on commencing to excavate, 35 feet from the shaft in the north heading, a pocket of sand showed in the roof, and water and sand flowed in. The heading was bulkheaded, and left until an air-lock could be put in, and work resumed using air pressure. Work continued on the east heading until December 4. At midnight, December 4 and 5,



Section 10, East Boston. Air Lock at East End of Siphon Tunnel under Chelsea Creek. April 12, 1898.

the water from the creek broke into the shaft, flooding the work. December 10 the shaft was pumped down by the Blake pump. The break was located from thirty-three to forty-two feet from the top, south-west side. Apparently the water had forced its way slowly behind the timbers and a greater hydrostatic pressure had resulted than the timbers could withstand. The break was repaired December 24, and the shaft was cleaned out by December 30. To prevent any further possibility of an accident of this kind occurring, a lining of concrete, having an oval opening 7 feet 8 inches by 8 feet 8 inches, was built in the shaft. Work was resumed on south heading January 15. January 17 putting in the air-lock was begun in the north heading. This air-lock was in January 26, and excavation under air pressure then commenced. January 20, a second shaft, called No. 3, was commenced near the site of the proposed East Boston pumping station. The shaft was down February 28. On the same date a heading was started northerly, and March 4, at 9 A.M., it met the heading from Shaft No. 1. While driving the tunnel a No. 5 pulsometer pump, running about one-half the time, took care of all the water. The estimated maximum amounts of water pumped in twenty-four hours from shaft and tunnel were respectively 580,000 and 65,000 gallons. March 13 the masonry between Shafts 1 and 3 was completed. The work in the north heading from the time of putting on air pressure progressed well. Ordinarily it was found necessary to support the roof only. Plates were put in from the springing line of the arch, every alternate foot or ring. While the excavation was hard-pan the circumferential length of one ring was nine feet; of the next, twelve feet. In the fine sand and silt, all the rings measured twelve feet. The length of each ring, measured on the line of the tunnel, was one foot, *i. e.*, the width of the plates. Between Sta. 2 + 21 and Sta. 2 + 31, the gravel and clay under the action of water worked into a jelly-like condition. The invert was here covered with two-inch planks, forming a cradle three feet four inches wide. In the bottom, Sta. 2 + 31 to Sta. 2 + 40 steel plates were used to form the cradle. Between Sta. 3 + 35 and Sta. 3 + 43 the clay was soft. In this bottom a cradle of planks, four feet eight inches wide, was put. Better progress was made through clay than through hard-pan, and better progress through sand or silt than through clay. The method of bracing was to excavate the roof of exact shape and hold it by plates made of one-eighth inch steel curved to proper radius, three feet long and one foot wide. The edges of the plates were reinforced with two-inch by one-quarter inch angles, through which bolts were passed to fasten together adjacent

plates. These were held up by spruce braces which were taken out as masonry was built. The bottom of the excavation was usually dug so as to fit the masonry. The tunnel for nearly its whole extent was lined with brick-work laid in Portland cement mortar. The theoretical thickness was twelve inches. In the arch, however, owing to variations in carrying the alignment, the thickness was often exceeded. Frequently where loose material was in the roof a plate would get slightly canted in being placed. This would have the effect of throwing the next plate upward, and before the tendency to rise was discovered it sometimes happened that the roof was a foot too high. No underdrain was used in the tunnel. At the north heading, where compressed air was used, the pressure was utilized to carry off the water. An iron pipe one and one-half inches in diameter was carried through the lock, and extended to the heading. At the heading was an ordinary stop-cock and a short piece of suction hose. Dropping the end of the suction hose into what water had accumulated in the heading, and opening the stop-cock, the pressure forced the water to the shaft. The headings between Shafts 1 and 3 met without any measured error. This part of the tunnel was on a curve of eighty feet radius, and the line was carried by offsets from chords forty feet long. The heading between Shaft No. 1 and the gate-chamber struck the sheeting of the gate-chamber excavation .013 feet to the right of line. The base from which this was run measured 5.66 feet, and was in a shaft continually dripping water. The tunnel was lighted by incandescent electric lamps. At a point half way across Chelsea River, where the roof was thin, an iron plate bound with angle irons and extending twenty inches below the crown of the arch was put in. The object of this was to make a diaphragm, behind which an air chamber would form, thus allowing the men to reach the lock with their heads above water should a break occur at the heading.

Average progress per week in tunnel under pressure, ...	24.8 feet.
Average progress per week in open tunnel from Shaft 1, . . .	18.0 "
Average progress per week in open tunnel from Shaft 3, . . .	13.0 "

It was thought that rapid progress in tunnelling under the river would be safer than slow progress. The more promptly the plates were put in the less liable was the earth roof to become demoralized. For this reason an extra payment was made to those in charge of tunnelling when progress exceeding an average of three feet per day for a month was made.

Sand Catcher, Etc.

Trench.

Length completed, ...	151 feet.
Average depth of excavation to bottom of pile caps, ...	21 "
Greatest depth of excavation to bottom of pile caps, ...	29 "

Cubic yards excavation per linear foot, 26.

Approximate cost of excavation per linear foot, including sheeting left in, excavation and refilling below masonry, $50.

Character of Earth Excavation. — Outside of sea-wall, downward from surface, about two feet of river mud, about eight feet of silt, then about seven feet of mixed sand and silt; inside of sea-wall, downward from surface, about four feet of gravel, about eight to ten feet of peat, about ten feet of silt, then about seven feet of mixed sand and silt.

Plant.

One steam derrick.
One incline.
One pile driver.
One 6-inch centrifugal pump.
One duplex steam pump, 8 inches by 8½ inches by 12 inches.
Three small steam pumps.

Account of Construction. — The cross-section of the sand catcher is similar to that shown for Section 7 on page 62 of the fourth annual report. Work was commenced Oct. 14, 1892, by driving round piles for a coffer dam around that portion which was outside of the sea wall which forms part of the causeway leading to the bridge. An open cut was started at the Chelsea end of old Chelsea bridge on the date just mentioned. The natural earth in this locality is very fine sand, kept in a semi-fluid condition by water which rises from an underlying stratum of gravel as described in the report for Section 12. To overcome this condition, two-inch pipes were driven into the underlying gravel and the water pumped from it. By this means the level of the ground water was lowered from its original level of six feet below the street surface to a depth thirty-two feet below the level of the street. Thirty of these wells have been driven in all, though only twelve or fourteen were pumped from at one time. The close proximity of the sea-wall proved a source of trouble. This wall was founded on piles, and underneath was a free passage for water. Many times water broke into the trench, causing delay. No underdrain was used. Ordinarily a small steam pump, throwing about a two-inch stream, took care of the water in the trench. At times, however, it was necessary to use the steam pump, together with a six-inch centrifugal pump. Pumping was from the bottom of the trench. The duplex pump was used for pumping from the driven wells.

Maximum,	. . . .	920,000	gallons.
Minimum,	. . . .	59,000	"
Average,	. . . .	276,000	"
Estimated ordinary amount of water pumped from driven wells in 24 hours,	. . . .	130,000	"

The structure is supported on piles, driven in bents of nine, four feet apart on centres. These piles are cut to an arc of thirty feet radius so as to make a concave platform, and caps made of six pieces of 2-inch by 12-inch spruce are fitted to this arc, and bolted to each pile with ¾-inch by 24-inch drift bolts. The platform is made of four-inch spruce planks. The piles average thirty-four feet in length. There have been numerous slight accidents to men. During the winter, when the ice covered everything, hardly a day passed without a man falling overboard. None of these men were hurt seriously, however. One serious accident occurred August 1. Joseph Conroy, who was at work on the pile driver, fell into the trench and broke his wrist and four ribs. During the winter the coffer-dam was completed and some digging done. There was a delay in receiving granite for the gate-chamber, and as this was the key of the whole work the balance waited with it. The masonry of the gate-chamber and overflow has been completed, together with about eighty-nine feet of that of the sand catcher.

Section 12 (Day Work), Chelsea.

Location. — On Marginal Street, for a distance of about 120 feet southwesterly from Eastern Avenue.

Character of Work: — To excavate for and partly rebuild about 94 feet of old sewer and to build about 22 feet of new sewer.

Diameter of sewer: —
8 feet 4 inches by 9 feet 2 inches.

Trench.

Depth of excavation to under side of pile cap,	. . . . . .	26.5	feet.
Average width top of trench,	. . . .	18.0	"
Average width bottom of trench,	. . . .	14.0	"

Cubic yards excavation per linear foot, 15.0.

Approximate cost of section per linear foot of trench and masonry, including driven wells, piles and platform, $54.00.

Excavation. — In the third and fourth annual reports an account was given of difficulties, settlement of street, demoralization of trench, delay, and settlement and cracking of sewer already built, caused by excavation of quicksand in the trench of Section 12 near Eastern Avenue. The work so injured has this year been re-excavated and as far as necessary replaced, and a short length not

then built has been constructed this year. Work was begun July 5, 1893, near Eastern Avenue. As already described in the above mentioned annual reports, the material here excavated is silt consisting largely of very fine sand. The difficulty in excavating the quicksand was caused by boiling springs, the water of which came from a coarse stratum about fifty feet below the surface of the street. In the fourth annual report an account is given, with illustrations, pages 71 to 73, of the method of almost completely removing this difficulty by sinking wells into this stratum and lowering the head of water below the bottom of the trench to be excavated. In making excavation for these repairs this method was again resorted to with complete success.*

The amount of pumping is approximately shown as follows: —

Average amount of water pumped from the pipe wells in 24 hours,	130,000	gallons.
Average amount of water pumped from trench in 24 hours, . .	106,000	"
Maximum amount of water pumped from trench in 24 hours, .	250,000	"

The excavation was slow on account of having to remove the large amount of bracing and timber left in the old trench. When the former trench was refilled nearly all the timber used in bracing and sheeting had been left in. Making another trench in the same place required considerable caution in cutting out and working around this old timbering. Starting from the beginning of the work, near Eastern Avenue, the condition when excavation was finished was as follows: First eleven feet, a pump well had been located and no sewer built. Next sixty-two feet, work had settled, and in some places had cracked. Next eleven feet, sewer not built. Next thirty-two and one-half feet, sewer had settled at one end 1.4 feet, and at the other end 0.1 foot.

Foundation. — The pumping operations described above had been so effective that the earth in the bottom of the trench was in almost an ideal condition, contrasting very strongly with that when the original excavation was made. At the time when the trench was open in 1891, an iron pipe, one-inch diameter, twenty feet long, was pushed its entire length below grade without difficulty. This year it was found impracticable to drive a two-inch plank with a heavy sheeting maul more than ten inches into the sand. An iron crow-bar dropped from the top, a distance of twenty-six feet, and striking fair on its point, it did not penetrate enough to enable it to stand upright in the bottom. In restoring the work it was

* A patent has lately been claimed by the man who superintended driving the wells. The plan in all essential particulars, however, had been devised by the writer and his assistants before either had ever heard of him or any of his work. The writer used a somewhat similar method twenty years ago, and he has lately learned that a method precisely like that described was used by the Newton city engineer in 1880.

decided, since no settlement had taken place for more than a year, to use that portion of the work already in which had settled but had not cracked, as a platform on which to found the new work. Where the old work was found to be cracked it was taken out and new work was built on piles and platform.

Section 12 (Contract Work), Chelsea.

Location. — In Marginal Street, from Eastern Avenue to about forty feet west of Shawmut Street. The first 116 feet included masonry which had been settled and cracked by quicksand excavation. Its rebuilding by the day is described elsewhere in this report.

Length of section, ... 3,035 feet.

Diameters of sewer, 8 feet 4 inches by 9 feet.

Contractor. — Orin P. Roberts of Cambridge, Mass.

Contractor's Superintendent (Year ending Sept. 30, 1893). — Charles G. Craib.

Contractor's Principal Foreman (Year ending Sept. 30, 1893). — R. G. Craib.

State Assistants (Year ending Sept. 30, 1893).

Inspectors: Francis L. Sellew, James E. Coyne.

Transitmen: Principals — Hartley L. White, Seth Peterson.

" Assistants — Edward S. Foster, Charles Kincaid, Thomas T. Cass.

Trench.

Length completed,	3,036.00 feet.
Average depth of excavation to bottom of pile cap,	27.00 "
Greatest depth of excavation to bottom of pile cap,	29.30 "
Average width top of trench,	14.80 "
Average width bottom of trench,	12.70 "

Cubic yards excavation per linear foot, 13.80.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, pile foundation, etc., $19.00.

Character of Earth Excavation. — Beginning of section to Highland Street, five feet of street filling on a few feet of peat and silt, below which was fine sand and silt; Highland Street to Shawmut Street, alternate strata of clay and gravel below the street surfacing.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$13 36
Brick-work, Portland cement mortar, per cubic yard,	14 41
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 35

Diameters of underdrain laid and length of each size: —

8-inch,	113 feet.
10-inch,	8 "
12-inch,	1,113 "

Approximate cost of masonry per linear foot, including underdrain, etc., $22.00.

Length completed, ... 3,014 feet.

Masonry begun, Aug. 4, 1891; finished, Feb. 2, 1893, except the above noted portion rebuilt by the day.

Approximate cost of section per linear foot of trench and masonry, including labor, material, driven wells, inspection and miscellaneous items, $45.00.

Note. — The information regarding Section 12 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the third and fourth annual reports.

Excavation. — The work was carried on from two openings. One opening (No. 1) was continued from about one hundred and fifty feet east of Highland Street to Highland Street, where it connected with the other opening. This latter opening (No. 2) was continued from about two hundred feet west of Charles Street to the end of the section. The excavated material in opening No. 1 was hoisted from the trench by means of derricks and taken back for back-filling by means of tram-cars, while in opening No. 2 like work was done by a trench machine. The distances covered by the operations from openings Nos. 1 and 2 were respectively one hundred and fifty and four hundred feet. In opening No. 1 the water was handled with a six-inch Blake pump attached to wells driven along the trench to the gravel stratum below, a little being pumped from the trench itself by a hand pump. In opening No. 2 the ground-water was handled by a six-inch centrifugal pump at a point about three hundred feet west of Charles Street and a pulsometer in the trench. At the times when the greatest amount of water was being pumped it is estimated that the quantities pumped at openings Nos. 1 and 2 were respectively 75,000 and 1,000,000 gallons in twenty-four hours. The ordinary progress per week in opening No. 1 was fifty feet; in opening No. 2, thirty feet. The work was not shut down at any time, although for two weeks in January but little was done owing to the severely cold weather.

Foundation. — Between Charles Street and Shawmut Street about one hundred and forty feet of the bottom of the trench was excavated to fit the invert of the sewer. Opening No. 1 was in quick-sand, which was handled by removing the water by means of driven wells, which process was described in the report of last year. A pile foundation for the sewer was put in from Congress Avenue to Highland Street. The piles were driven in five-pile bents about four feet apart and capped with ten-inch by twelve-inch timbers, which formed the sills of the four-inch floor. The piles varied in length from five to twenty-seven feet below the cap, averaging about eighteen and one-half feet.

Difficulties. — A spring was encountered near the foot of Shawmut Street. This filled the trench to a depth of about six feet and delayed work on the masonry for about two weeks.

Miscellaneous. — The crown of the arch at no place came nearer the surface than twelve feet. Some of the surplus earth was used for filling an adjacent marsh, and some was used to make a dyke for protection against tidal encroachments.

Section 14, Chelsea.

Location — From a point in Marginal Street 40 feet west of Shawmut Street, through Marginal Street to Hawthorn Street, thence on the line of Marginal Street extended for 200 feet through private land to near Pearl Street, thence through private land to Chelsea Square, thence through Second Street to a point about 100 feet north-west of Spruce Street.

Length of section,	3,445 feet.
Diameters of sewers and length of each size: —	
8 feet 10 inches (circular),	1,586 feet.
8 feet 4 inches by 9 feet,	1,749 "
8 feet 2 inches by 8 feet 10 inches	110 "

Contractors. — Metropolitan Construction Company of Boston, Mass.

Contractor's Superintendent (Year ending Sept. 30, 1893). — George W. Judd.

Contractor's Principal Foremen (Year ending Sept. 30, 1893): —

Trench — William Lindsey, James Long.

Tunnel — Thomas Murphy, Colin Cameron.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer: Seth Peterson.

Inspectors: M. F. Garra, James J. Conway, John D. Collins, James E. Coyne.

Transitmen: Principals — Seth Peterson, Fred Brett.

" Assistants — Charles Kincaid, Thomas T. Cass.

Trench and Tunnel.

Length completed of trench excavation,	1,862.00 feet.
Length completed of tunnel excavation,	1,583.00 "
Average depth of trench excavation to bottom of underdrain,	28.60 "
Greatest depth of trench excavation to bottom of underdrain,	37.00 "
Average width top of trench,	14.50 "
Average width bottom of trench,	12.10 "
Average depth from surface of ground to bottom of tunnel underdrain,	37.00 "
Greatest depth from surface of ground to bottom of tunnel underdrain,	45.50 "
Average width of tunnel excavation,	11.10 "

Cubic yards trench excavation per linear foot, 14.50.

Cubic yards tunnel excavation per linear foot, 4.20.

Approximate cost of trench and tunnel per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $28.

Character of Earth Excavation. — Approximate cross-section from beginning of section to Shurtleff Street, 17½ feet of sand and gravel, 3 feet of clay, sand. The sand was quite wet up to about 3 feet above water line of sewer. Shurtleff Street to Chelsea Square: sewer built in tunnel, surrounded by clay. Chelsea Square to Chestnut Street: tunnel, sewer first surrounded by quick-sand, later clay in top and gradually running down until it finally surrounded the sewer. Approximate cross-section from Chestnut Street to Ash Street: 1½ feet of surfacing, 4½ feet of sand and gravel, clay to about 3 feet above water line of sewer, then quicksand. Approximate cross-section from Ash Street to end of section: upper 8 feet, sand and gravel, then 3 feet of peat, then clay; the only exception being that gravel took the place of the latter for one hundred feet near Spruce Street.

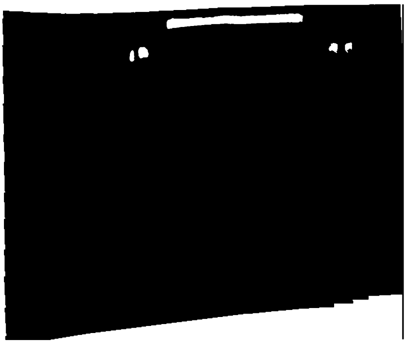
Contract price: —
Brick-work, American c
Brick-work, American c
Brick-work, Portland ce
Brick-work, Portland ce
Concrete, American ceme
Concrete, American ceme
Concrete, Portland ceme
Concrete, Portland cemer
Diameters of underdrain la
4-inch, ...
6-inch, ...
10-inch, ...
12-inch, ...
Approximate cost of mason
drain, etc., $20.00.
Length completed, trench,
Length completed, tunnel,

Masonry begun in tunnel, .
Masonry begun in trench, .

Approximate cost of section
labor, material and inspec
increased by claims now pe

NOTE. — The information re
the year ending Sept. 30, 1893
this year, see the fourth annua

Open Cut Work. — O
by means of trench mac
ation from last year's wo
the school-house, to nea
hundred and twenty-fou
was thirty feet. The fo
from which the water wa
the gravel, as described
with these were three six-
of the school house. The
one foot above that of the
the pressure that with th
which was handled by a
The amount pumped was
per twenty-four hours. T
was increased to twenty in
Second Street, near Popl
south corner, and the bloc
one and one-half inches b
about the trench. A wood



Second Streets was slightly disturbed from the same cause. The second opening was started March 21, 1893, on Marginal Street at Shurtleff Street. Operations from this extended to the beginning of the section, a distance of about five hundred and forty-eight feet. The average progress per week was about forty feet. In the beginning of the work here, the ground-water was handled by a six-inch pump and pulsometer located about half way between Magee's Foundry and Phillips & Hodgdon's coal wharf. After a short time an eight-inch pump was located opposite Magee's Foundry, and that alone handled all the water. The foundation for all the open-cut work was excavated to a depth of about six inches below the bottom of the masonry and refilled with gravel. Both in Second Street and in Marginal Street, local sewers have been relaid on platforms supported by posts standing on piers built upon the arch of the Metropolitan sewer.

Tunnel Work. — On Second Street a heading was started from the end of the trench toward Broadway Square. The end of the trench which was used as a shaft was about fifty feet north-west of Chestnut Street. When the sewer had been built some sixty feet in this heading the laying of the masonry was stopped for a time and the timbering was run ahead about one hundred and sixty-five feet from the shaft. Here fine running sand appeared in such quantities that it was thought best to finish the work to this point before drifting further. For a distance of about one hundred and thirty feet from the shaft the bottom of the excavation was shaped to fit the invert of the sewer. The average progress to this point was 16.7 feet per week. The sand in the bottom then became very troublesome, and it seemed dangerous to continue excavating lest the sand should run from underneath the work already built and cause it to settle. Work was accordingly suspended on November 8. On November 10 came a very heavy storm, and the tunnel was flooded by water, from the streets and local sewers, coming into the shaft and the open trench in the rear. The clay on which the timber roof was supported became soft and allowed the legs in the drift ahead of the masonry to settle gradually through into the sand. This caused the street surface to settle some four feet for a length of thirty-five feet. No damage resulted from this, either to adjacent buildings or to the masonry, beyond pushing out of place a few bricks at the toothing, by the lagging doubling and breaking as the timber ahead settled. From the end of the masonry already built to the Broadway shaft the work was carried on under air pressure, the roof being lined with flanged curved plates bolted to each other sim-

Section 14, Chelsea. Slip in Tunnel Drift under Second Street, near Chestnut Street. November 11, 1892.

Section 14, Chelsea. TUNNEL HEADING UNDER SECOND STREET, NEAR CHERRY STREET. AXIAL BEAM AND STEEL PLATES.
January 21, 1893.

ilar to those used at the Pearl Street shaft. The time from November 8 to 29 was employed in constructing air-locks and placing machinery. On the 29th of that month a small air compressor was started, and during the night five rings of plates were put in. After this good progress was made. On Jan. 6, 1893, a second compressor was added, and thereafter both were run. The work went on until February 9, when about two hundred and thirty feet had been built under air pressure at an average rate of 22.9 feet per week. Meanwhile the character of the earth had been gradually changing, and about this time the sewer passed wholly below the top of the stratum of quicksand. The escape of air was then so great that the necessary air pressure could not be maintained, and on the 11th work was therefore suspended until another compressor could be obtained. The third compressor was started on the 17th, and with the extra pressure thus derived another section about fourteen feet in length was completed. In the following section, however, the pressure could not be maintained, and work was again discontinued on the 21st until machinery of greater capacity should arrive. On March 5 a 100-horse power vertical boiler and two more large compressors were set in operation, making five compressors in all. These were kept running to the end of the work. With all five running, however, the excavation could only be carried to a point about one and one-half feet above the bottom of the masonry, the ground below this being saturated with water. It was then suggested that, as the leakage of air was at the top, the air might be held in sufficient quantity to allow excavating the bottom and laying the masonry by starting as low as possible and putting in a concrete lining to the sides, roof and breast of the heading. This method of holding the pressure was successful. It was then thought that if the arch was built first the same result might be obtained without the use of concrete, and this proved to be the case. The arch was built on wall-plates, and these and the arch were supported by braces from the axial or needle-beam in the same manner as were the plates. The invert was then built up to the wall plates, which were taken out. The space so left was filled with brick. After building forty-six feet in this manner, clay again appeared in the bottom and work went on in the regular way, although the last section was delayed by the timbering driven in from the Broadway shaft. Through the quicksand tunnel the masonry was increased from twelve inches to sixteen inches in thickness. The average progress for the last one hundred and five feet, deducting the time of suspension while waiting

for compressors, was 13.6 feet per week; or, without this deduction, 9.5 feet per week. The average for the whole distance built under air pressure, counting from the time the first compressor was started, was sixteen feet per week. The cost per linear foot of completed work of this portion (with thicker masonry) was $56.60, and in the headings where compressed air was not used (with thinner masonry) it was $46.37. The cost is that to the Commonwealth, according to the regular estimates for payments to the contractors. The amount of air compressed is roughly estimated as shown in the following table: —

Approximate Estimate of Air Compressed.

TIME.	Compressors.	Cubic Feet per Minute.
November 9 to January 6,	1	About 135
January 6 to February 17,	2	" 330
February 17 to March 5,	3	" 850
March 5 to April 25,	5	" 1,400

Up to about March 1 there was no gauge to determine the amount of air pressure in the headings. After that date the gauge showed a pressure of from three to six pounds per square inch, according to the condition of the heading, the maximum being reached at the completion of a section of masonry. After the masonry was finished the air was kept on for a few days while some holes were being filled which had been cut to make the experiment of grouting over the arch. During this time the smallest compressor of the five could scarcely be run slowly enough to keep the pressure at five pounds per square inch.

There was one fatal accident at this shaft, which occurred as follows: At about 10 o'clock in the forenoon of December 18 a loaded car was brought up. Peter Maginn received it at the top and pushed it from the elevator. He should then have placed the guard chain, but failed to do so. Instead, he pushed the car along the run to the dump and ran it back empty to the shaft, from which the elevator had been dropped. Maginn lost his balance and fell after the car to the bottom of the shaft, sustaining injuries from which he died in the hospital in the latter part of the afternoon of that day.

There was one other tunnel heading on this section (a continuation from last year's work), and operations in it progressed east a distance of about one hundred and twelve feet to Shurtleff Street.

It was a timbered tunnel, all in clay, and the bottom of the excavation was shaped to fit the invert of the sewer. The ordinary progress per week was about twenty-five feet.

SECTION 16, EVERETT.

Location. — In Second Street, from the Chelsea line to the tracks of the Eastern Division of the Boston & Maine railroad, thence westerly on the south side of the tracks for about 1,700 feet, thence across the marsh to Broadway near the northerly end of Bow Street.

Diameters of sewers, and length of each size: —

8 feet 2 inches by 8 feet 10 inches,	3,573 feet.
5 feet 10 inches by 6 feet 4 inches,	843 "

Contractors. — R. A. Malone & Son of Philadelphia, Penn.

Contractors' Superintendent (Year ending Sept. 30, 1893.) — Michael Tallant.

Contractors' Principal Foreman (Year ending Sept. 30, 1893.) — James Carroll.

State Assistants (Year ending Sept. 30, 1893.)

Inspectors: Samuel Corning, Warren A. Rogers.
Transitmen: Principal — Paul W. Rowell.
" Assistants — Fred Brett, George H. Chase, George R. Winslow.

Trench.

	Larger Size.	Smaller Size.
Length completed, feet,*	3,573.00	843.00
Average depth of excavation to bottom of underdrain, feet,	20.10	20.70
Greatest depth of excavation to bottom of underdrain, feet,	28.20	25.20
Average width top of trench, feet,	14.00	9.70
Average width bottom of trench, feet,	13.60	9.00
Volume of excavation per linear foot, cubic yards,	9.10	6.40
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, bonus paid to contractors on account of dykes, etc.,	$17 00	$10.00

* Excavation for bell-mouth (irregular shape) was also made.

Character of Earth Excavation. — Cross-sections at various points — Beginning of section, at Chelsea line; three feet of gravel road-surfacing, peat to two feet below water line of sewer, where firm clay is encountered. Where sewer leaves Second Street: mixed sand and gravel down to water line of sewer, where clay is encountered. At a point about opposite East Everett depot; three feet of peat with clay underneath. The last seven hundred feet of the trench was through clay overlaid with eight inches of loam.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	14 25
Concrete, American cement mortar, per cubic yard,	5 50
Concrete, Portland cement mortar, per cubic yard,	6 25

Foundation. — The clay forming the bottom of the trench was excavated to fit the invert of the sewer for a distance of about five hundred feet on the marsh between the large railroad culvert and the bell-mouth. At a point about three hundred feet easterly from the large railroad culvert fine running sand was encountered near the bottom of the sewer at the water line. This sand was drained from both ends and replaced by coarse gravel to a depth of two feet.

Miscellaneous. — The sides of the embankment at the two creeks between Everett and East Everett were protected by riprap. The crown of the arch comes within about two feet of the bottoms of the creeks where the sewer passes under the same. The bottom of the creek near the large railroad culvert was paved with blocks set in Portland cement. The bottoms of the other creeks were refilled with clay to their original lines. The crown of the brick sewer in each of the two latter cases is re-enforced with one foot of Portland concrete. An embankment to a fairly regular height of about two feet above the natural surface was built over the sewer on the marsh, and it is understood to conform to the wishes of the land-owners.

Section 17, Everett.

Location. — From the junction of Broadway and Bow Street, through private lands, across the Eastern and Saugus Branch railroads, through Fleet, Cross and Williams Streets, and along the Saugus Branch railroad to Waters Avenue, thence curving to the left and through marsh lands for 220 feet toward the Malden River.

Diameters of sewers and length of each size: —

5 feet 10 inches by 6 feet 4 inches,	3,304 feet.
4 feet 8 inches by 5 feet 1 inch,	225 "

Contractor. — Christy McBride of Brighton, Mass.

Contractor's Superintendents (Year ending Sept. 30, 1893.) — Bernard Devine, Neil Devine.

Contractor's Principal Foreman. — Harry De Graff.

State Assistants (Year ending Sept. 30, 1893.)

Inspector: George A. Chase.
Transitmen: Principals — Paul W. Rowell, Fred Brett.
" Assistants — George F. Chase, George R. Winslow.

Trench.

Length completed,	3,542.00 feet.
Average depth of excavation to bottom of underdrain,	21.40 "
Greatest depth of excavation to bottom of underdrain,	32.50 "
Average width top of trench,	9.30 "
Average width bottom of trench,	8.70 "

Cubic yards excavation per linear foot, 6.10.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $7.00.

Character of Earth Excavation. — Through three feet of peat to firm clay, except from Wellington Avenue to Norman Street, where gravel was encountered.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$13 60
Brick-work, Portland cement mortar, per cubic yard,	15 00
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid and length of each size:—

4-inch,	232 feet.
6-inch,	92 "
8-inch,	2,676 "
10-inch,	800 "

Approximate cost of masonry per linear foot, including underdrain, etc., $9.09.

Length of masonry completed, ... 3,542 feet.

Masonry begun, Sept. 22, 1891; finished, Jan. 10, 1893.

Approximate cost of section per linear foot of trench and masonry, including labor, material, inspection, and miscellaneous items, $18.00.

NOTE.—The information regarding Section 17 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the third and fourth annual reports.

Excavation.—Earth was removed by means of a derrick. Operations were mainly carried on from an opening about midway between the Eastern and Saugus Branch railroads, from which the excavation extended to the foot of Fleet Street, a distance of about eight hundred feet. In addition to this about fifty feet of trench was dug, back from the junction with Section 40, near Waters Avenue. To take care of the ground-water, a six-inch centrifugal pump was used near Waters Avenue, a hand pump near the foot of Fleet Street, and a six-inch centrifugal pump at Broadway near the beginning of the section. It is estimated that the amount of water pumped per twenty-four hours at times of maximum pumping was 400,000 gallons at opening near Waters Avenue, and 150,000 gallons at the opening near Broadway. The weekly progress of excavation at each opening was about forty-eight feet, and the work was pursued without shut-downs.

Foundation.—The bottom of the trench was excavated to fit the invert of the sewer for the entire length of this year's work.

Miscellaneous.—A woman in a house near Henderson Avenue was slightly injured by a piece of clay which went through the window during the blasting of frozen backfilling. On the marsh an embankment was built over the sewer to a height of about two feet above the natural surface.

SECTION 20, MEDFORD.

Location.—From a point about 600 feet east of the Wellington station, through marsh, crossing the Boston & Maine railroad to Third Street, through this street, private land, Ship Street and Riverside Avenue to Park Street. In this section is also included the Edgeworth branch, which extends through Craddock Avenue and the projected location of Pearl Street to a point in Malden about 50 feet north of the Medford line. The lower end of the section, on marsh, adjoins the location of the proposed sand-catcher and siphon under Malden River, to connect with Section 17½.

Diameters of sewers, and length of each size: —

4 feet 8 inches by 5 feet 1 inch (main line),	1,429 feet.
4 feet 5 inches by 4 feet 8 inches (main line),	6,218 "
2 feet (Edgeworth branch),	1,523 "

Contractor. — John Sheehan of Lynn, Mass. Mr. Sheehan acted as his own Superintendent.

Contractor's Principal Foreman (Year ending Sept. 30, 1893). — Michael Bowles.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer and Inspector: John S. Hodgson.

Trench.

	Main Line.	Edgeworth Branch.
Length completed, feet,	7,647.00	1,523.00
Average depth of excavation to bottom of underdrain, feet,	18.50	13.30
Greatest depth of excavation to bottom of underdrain, feet,	23.70	17.00
Average width top of trench, feet,	7.85	5.75
Average width bottom of trench, feet,	7.00	4.75
Volume of excavation per linear foot, cubic yards,	4.70	2.60
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc.,	$4 00	$2 00

Character of Earth Excavation. — The greater part of the main line trench was in good clay bottom, with sand and loam above. A portion of the remainder of the bottom was loamy sand, with some gravel, and boulders in places. The ground east of Boston & Maine railroad, was silty at bottom, with wet sand and marsh mud above. The Edgeworth branch excavation was mainly in wet sand, with clay in places. Marsh mud was encountered at the upper end of this branch.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 70
Brick-work, Portland cement mortar, per cubic yard,	14 00
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid and length of each size: —

6-inch,	3,969 feet.
8-inch,	4,393 "
10-inch,	846 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc.: —

Main line,	$7 00
Edgeworth branch,	3 00

Length completed, main line, 7,647 feet; Edgeworth branch, 1,523 feet, 9,170 feet.

Masonry begun, Oct. 28, 1891; finished, July 1, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items: —

Main line,	$11 00
Edgeworth branch,	6 00

Note. — The information regarding Section 20 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — On the main line the digging and backfilling was done by means of a trench machine. This year's work was from Spring Street along Riverside Avenue to Park Street, a distance of about two thousand and thirty-nine feet. The ground-water at this opening was handled by an eighteen horse-power engine and a six-inch centrifugal pump. The ordinary progress per week was one hundred and twenty linear feet. There were two openings on the Edgeworth branch, and the trench excavated this year was from near First Street, across the railroad and creek, to a point in Malden about fifty feet north of the Medford line, a distance of about one thousand and twenty-one feet. The above mentioned pumping apparatus was moved to this work and was used in removing the ground-water. The ordinary progress of excavation per week was seventy feet. Hand pumps were occasionally used on short lengths where the underdrain was omitted or became choked. Work ceased for a month, in February and March, 1893, on account of severe weather.

Foundation. — The bottom of the trench was chiefly clay and was shaped to fit the invert for the greater part of the main line sewer built this year, the exception being two lengths aggregating about nine hundred and eighteen feet, between Foster's Court and Park Street, where a double timber cradle was employed. Where much ground-water was encountered on the Edgeworth branch double-timber cradling was employed. Elsewhere a concrete reinforcement of the invert was used. At and adjoining the creek crossing on the Edgeworth branch a length of two hundred and forty feet was in peat and silt. This was removed to a maximum depth of seven feet in order to reach the underlying clay, and was refilled with gravel and broken stone Portland concrete.

Difficulties. — The creek forming the division between Malden and Medford was crossed by a single line of twenty-four inch Akron pipes, jointed in Portland cement and surrounded by broken stone Portland concrete. The sockets of these pipes are three inches below the bed of the stream, and the concrete covering on top is to bed level. Coffer-dams were erected to exclude the tides. The Edgeworth branch sewer (surrounded by concrete) crossed under the Medford branch of the Boston & Maine railroad. The railroad train service was not interrupted. The Edgeworth branch trench was sometimes flooded by tides.

Miscellaneous. — An Italian laborer had his leg broken by the pick axe of another workman, on Jan. 19, 1893. The following

city structures were carried over the Metropolitan sewer: An eight-inch pipe sewer and a twelve-inch storm-water pipe near Spring Street and an eight-inch pipe sewer at Lapham Street, all in Riverside Avenue. In each case the pipes were jointed in Portland cement and laid upon a concrete wall, two feet thick, carried up from the springing of the arch. On Riverside Avenue the surplus earth gained was chiefly disposed of on a lot owned by the Contractor. On the Edgeworth branch almost the whole of the nominal surplus went to replace sand dug from the trench and used along the whole line of the work for brick-work and concrete.

Section 21 (Minor Contract Work), Medford; Crossing Gravelly Brook.

Location. — On Riverside Avenue, across Gravelly Brook, connecting contract work previously built.

Length of work, ...	about 54 feet.
Diameters of sewers and length of each size: —	
4 feet 5 inches by 4 feet 8 inches masonry sewer, ...	46 "
4 feet 6 inches iron pipe, ...	8 "

Contractors and their Superintendents.

William H. Lenox of Medford, Mass., for extra work on culvert and placing pipe. Mr. Lenox acted as his own superintendent.

A. W. Bryne of Somerville, Mass., for masonry at ends of pipe through walls of culvert, and for sewer connecting pipe crossing Gravelly Brook with the ends of the gap — A. E. Weaving being superintendent.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspector: Hudson B. Damon.
Transitman: Assistant — Burton A. Clark.

Culvert, and Pipe.

Cost of extra work on culvert; pipe, etc.: — $1,124.
Pipe laying and brick-work at ends of pipe finished Feb. 24, 1893.
Masonry of culvert finished April, 1893.

Trench and Masonry.

(Each side of Culvert to connect with Contract Work.)

Cost of work, including excavation, concrete and brick masonry, pumping, refilling, $831.
Work begun, July 10, 1893; finished, July 28, 1893.

The City of Medford under a contract with Wm. H. Lenox of Medford rebuilt the Gravelly Brook culvert in Riverside Avenue during the winter of 1892–1893, and arrangements were made Dec. 19, 1892, by the Board with Mr. Lenox and the City of Medford by which the above described iron pipe was placed across the stream, the ends being surrounded by masonry in the walls of the

culvert. The bottom of the culvert as now built passes by a reversed curve under the pipe. The top of the culvert was raised one and three-fourths feet higher over the pipe. The natural flow of Gravelly Brook at the lower stages of the tide is under the pipe. At higher stages of the tide it can pass both over and under. For a foundation for the culvert, piles were driven in bents four feet apart, on which were placed twelve-inch by twelve-inch wooden caps and a wooden platform six inches in thickness over which concrete one foot in thickness was laid. The walls of the culvert are of rubble masonry six feet thick at the bottom and two feet thick at the top, laid in cement. The top of the culvert is covered with split granite eighteen inches thick. About three and one-half feet of the brick sewer was built through the walls of the culvert at each end of the pipe and the ends of the pipe surrounded with brick masonry. In excavating for the thirty-nine feet of the gap remaining (a portion on each side of the culvert), from two to three feet of peat was found below the grade of the sewer. This peat was removed and a concrete foundation put in.

Section 21 (Day Work), Medford; Crossing Creek East of Winthrop Street.

Location. — Adjoining and easterly from Winthrop Street, at creek; connecting contract work previously built.

Length of work, ... 181 feet.

Structures.

4 feet 3 inches by 4 feet 6 inches masonry sewer, ... 171.25 feet.
Overflow and gate-chambers by the side of the above.
4-foot iron pipe, ... 9.75 "

Assistants.

Assistant Engineer: Edmund S. Davis.
Foremen: Charles G. Craib, James E. Carter, Patrick McCarthy.
Transitman: Assistant — Burton A. Clark.

Cost Data.

Pipe and sleeves, delivered in Medford, excavation, masonry, etc., $11,220.
Work begun, April 5, 1893; finished, Sept. 7, 1893.

The sewer passes over the creek in an iron pipe between two side walls of coursed granite. The natural flow of the stream at the lower stages of the tide is under the pipe. At higher stages of the tide it can pass both over and under. The bed of the stream is paved with granite blocks laid in a bed of concrete. Cast iron sleeves are so arranged in the side walls that the pipe can be taken out if necessary and renewed without disturbing the masonry. An overflow is arranged on the southerly side of

the sewer at this point, with double tide gates. Stop-plank manholes are provided for across the sewer just east of the overflow, and also across the overflow in the southerly side of the sewer. The course of the stream was temporarily changed to allow of this construction. The trench for the sewer between the overflow and Winthrop Street was excavated from one and one-half to two feet below grade to remove all peat. Concrete was used to refill to the bottom of the standard section of the sewer. The masonry work was finished Aug. 10, 1893, since which time an embankment of earth four feet over the crown of the arch, six feet wide on top, with side slopes of two to one, has been built and a portion of the northerly slope about fifty feet long, next to the creek east of Winthrop Street, has been protected by rip-rap or rough slope paving. About twenty feet of the embankment on each side of the culvert has also been protected by hand-laid rip-rap.

SECTION 22, WEST MEDFORD.

Location. — Through Canal Street, from its junction with Prescott Street, across High Street and through Warren Street, crossing a brook near Irving Street, thence crossing private lands, Irving Street and private lands again and along the easterly side of the Boston & Lowell railroad, across Grove Street to a point about 1,200 feet north of Grove Street, thence across the railroad and private land to near the Mystic dam.

Diameters of sewers and length of each size: —

3 feet 4 inches by 3 feet 6 inches, including bell-mouth at Alewife Brook branch,	6,033 feet.
2 feet 10 inches by 3 feet (Alewife Brook Branch to Sta. 0 + 22),	18 "
4 feet 3 inches by 4 feet 6 inches (extension of Section 21 to bell-mouth near beginning of Section 22),	5 "

Contractor. — Andrew W. Bryne of Somerville, Mass. Mr. Bryne has acted as his own superintendent.

State Assistants (Year ending Sept. 30, 1893.)

Assistant Engineer: Edmund S. Davis.
Inspectors: Henry M. Woodward, Hadson B. Damon.
Transitman: Burton A. Clark.

Trench and Tunnel.

Length completed of trench excavation,	4,769.00 feet.
Length completed of tunnel excavation,	559.00 "
Average depth of trench excavation to bottom of underdrain,	23.00 "
Greatest depth of trench excavation to bottom of underdrain,	31.00 "
Average width top of trench,	8.00 "
Average width bottom of trench,	6.33 "
Average depth from surface of ground to bottom of tunnel underdrain,	28.00 "
Greatest depth from surface of ground to bottom of tunnel underdrain,	42.00 "
Average width of tunnel,	5.50 "
Cubic yards trench excavation per linear foot,	6.06 "
Cubic yards tunnel excavation per linear foot,	1.25 "

$9.00.

Character of Earth Excavation. — Sand and gravel near the surface; very fine running sand in lower part of the trench, and in some places this is mixed with clay. Six per cent. of a sample of this fine sand was retained in a sieve having 32,400 meshes to the square inch.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$13 50
Brick-work, Portland cement mortar, per cubic yard,	15 50
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	7 00

Diameters of underdrain laid, and length of each size: —

6-inch,	1,474 feet.
8-inch,	3,220 "
10-inch,	224 "

Approximate cost of masonry to date (September 30) per linear foot of trench and tunnel, including underdrain, etc., $6.00.

Length completed, trench,	4,678 feet.
Length completed, tunnel,	400 "

Masonry was begun in trench, March 24, 1892, and is now (September 30) in progress.

Concrete masonry was begun in tunnel March 8, and brick masonry March 11, 1893; and is now (September 30) in progress.

Approximate cost of section to date (September 30) per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items, $16.00.

Note. — The information regarding Section 22 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation and Tunnel Methods. — A trench machine and an "A frame" derrick have been used. Operations have been carried on from two openings. The first of these, a continuation from last year's work, extended northerly from a point about eight hundred feet north of the West Medford Station for a distance of about one thousand six hundred and twenty feet, crossing beneath three small brooks. The second opening was begun Jan. 20, 1893, near the northerly end of the section, west of the Boston & Lowell railroad, and operations from it have now covered a distance of about one thousand five hundred and forty-three feet to Grove Street Bridge. A tunnel was begun at a shaft about one hundred feet west of the Boston & Lowell Railroad. Headings have proceeded from this shaft as follows: One westerly to the upper end of the section; the other easterly, crossing under the railroad tracks and around the curve of forty feet radius east of the track, to the portion of the line which runs parallel with and on the easterly side of the railroad. The length of this tunnel, including both headings, was three hundred and sixty-four feet.

A second tunnel was from a point one hundred and nineteeen feet southerly from the easterly end of the one just described, and ran southerly, parallel with the railroad, for a distance of thirty-six feet. The third tunnel, the one on which work is being done at the present time, September 30, is from a point about one hundred feet north of Grove Street Bridge, running southerly to pass under the easterly abutment of the bridge. The operations have now progressed for a distance of one hundred and fifty-nine feet. The timbers used for legs and caps in these tunnels were eight-inch by eight-inch spruce, in sets about five feet apart. Two-inch spruce plank have been used for the lagging, excepting under the Grove Street Bridge, where three-inch plank have been used for the overhead lagging. The portion of the tunnel under the railroad was backfilled with concrete over the arch of the sewer. In other places the sewer tunnel arch was backfilled with earth. For pumping ground-water there have been a six-inch centrifugal pump, a three-inch Knowles pump and a No. 5 pulsometer, used at pump wells and sumps along the line as needed. It is estimated that the maximum amount of pumping done in any twenty-four hours was 500,000 gallons. The average progress of excavation per week at each opening has been about forty-eight feet, but where everything has been favorable about sixty-four feet has been made. On the lower opening a derrick frame was used at first. There was a shut-down which lasted three months. When work was resumed it was with the trench machine, taken from the upper opening where work was then proceeded with by tunnelling.

Foundation. A very fine running sand with some clay is met along the easterly side of the railroad in the lower part of the trench. For most of this trench the bottom of the excavation has been carried down below the bottom of the masonry and refilled with gravel, this lower excavation being generally to a depth of six inches.

Accidents. — Last November, while Carl Taylor was laying underdrain, he was struck and had several of his ribs broken by a falling bucket which had been unhooked by a plank placed in its way across the trench. July 15, just after working hours, a young man employed as a plank driver, was struck and killed by a train as he was crossing the railroad track opposite the trench above Grove Street. There were also several minor accidents during the year.

Location. — From a point on the marsh about 1,150 feet north-easterly from Beacham Street, southerly through marsh lands, and Ashland, Beacham and Bow Streets to Lynde Street.

Length of section, ... 2,268 feet.

Diameter of sewer: —

6 feet by 6 feet 8 inches.

Contractors. — R. A. Malone & Sons of Philadelphia, Penn.

Contractors' Superintendent (Year ending Sept. 30, 1893.) — Michael Tallant.

Contractors' Principal Foreman (Year ending Sept. 30, 1893.) — Dennis Hayes.

State Assistants (Year ending Sept. 30, 1893.)

Inspectors: Warren A. Rogers, George A. Chase, Samuel Corning, Hudson B. Damon.

Transitmen: Principal — Paul W. Rowell.

" Assistants — Fred Brett, George F. Chase, George R. Winslow.

Trench.

Length completed,	2,268.00	feet.
Average depth of excavation to bottom of underdrain,	25.30	"
Greatest depth of excavation to bottom of underdrain,	34.50	"
Average width top of trench,	10.50	"
Average width bottom of trench,	9.20	"

Cubic yards excavation per linear foot, 8.50.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $9.00.

Character of Excavation. — First one thousand feet of section (across marsh), 3 feet of peat at surface, underlaid with firm clay; through Ashland Street, 1 foot of loam underlaid with clay: through Beacham Street and about 100 feet in Bow Street, 2 feet of gravel road surfacing, 8 feet of sandy clay, underlaid with firm clay: thence to Thorndike Street, material below 2 feet of road surfacing was sand except from Courtland to Thorndike Street, where rock averaging 6 feet deep was encountered in the bottom. The remainder of section was mainly clay below two feet of road surfacing.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	13 75
Concrete, American cement mortar, per cubic yard,	5 75
Concrete, Portland cement mortar, per cubic yard,	7 00

Diameters of underdrain laid, and length of each size: —

8-inch,	2,207	feet.
10-inch,	60	"

Approximate cost of masonry per linear foot, including underdrain, etc., $9.00.

Length completed, ... 2,268 feet.

Masonry begun, Oct. 16, 1891; finished, March 22, 1893.

Approximate cost of section per linear foot of trench and masonry, including labor, material and inspection, and miscellaneous items, $20.00.

NOTE. — The information regarding Section 23 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Excavated material was handled by means of a derrick, from a point on Bow Street half way between Courtland and Thorndike Streets to the end of the section at Lynde Street, a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Foundation. — Ro
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sand and gravel, and
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Miscellaneous. — F
Bow Street a twelve-i
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about one foot from
earth was left on the

SECTION 2

Location. — From the end o
the causeway
under Mystic
bridge, to Tu

Length of section,

Diameters of sewers and len
6 feet by 6 feet 8 inches fro
Length for Pumping Statio
5 feet circular (Siphon),

Superintendent of tunnel
Foremen: Henry Hertz,
Transitmen: Principals –
" Assistants –

Length completed, September
Average depth below floor of
Greatest depth below floor of
(Sump), ...
Average width of excavation,
Cubic yards excavation per lin

Approximate cost of tunnel
including superintendence, p

Character of Earth Excavation. — Upper eleven feet of shaft in Tuft's mill pond, miscellaneous filling partially decomposed; next ten feet, sand; balance of shaft, clay, gravel and small stones. Tunnel excavation thus far: mainly pure clay with occasional thin strata of sand, and small stones.

Brick Masonry.

Volume of brick-work, Portland cement mortar, per linear foot, . 0.815 cub. yds.
Approximate cost of brick-work per linear foot, $16.00.
Length of masonry completed, ... 425 feet.
Masonry was begun, July 3, 1893, and is now (September 30) in progress under Mystic River.
Approximate cost of tunnel per linear foot of excavation and masonry to date (September 30), $49.00.

Construction. — The plant for the work has consisted of one vertical air-lock, used in sinking shaft; one horizontal air-lock for driving tunnel; one Ingersoll air compressor, sixteen inches by twenty-four inches, capacity at ninety revolutions — three hundred and fifty cubic feet of air per minute; one Ingersoll air compressor, eighteen inches by twenty inches, capacity at ninety revolutions — three hundred and seventy-five cubic feet of air per minute; one air receiver; three vertical boilers, forty-five inches by one hundred and eight inches; one Lidgerwood hoister, six inches by eight inches; one Harrisburg "Ideal" engine; one Westinghouse dynamo, capacity sixty-six incandescent electric lights; and one No. 5 pulsometer. Ground was broken for the shaft April 22, 1893, at a point about fifty feet from Mystic River at the southerly end of Malden Bridge. A shaft twenty-four feet by twenty-six feet was excavated to a depth of twenty-eight feet, through filling, coarse sand, and about two feet into good clay. Inside of this another shaft was built, size eight feet by ten feet, and the space between the two was filled with well tempered clay. The smaller shaft was then carried down to a depth of forty-nine feet. In carrying the smaller shaft down, water appeared in large quantities at a depth of thirty-four feet; there apparently being at this depth a vein of open material which had connection with the water in the mill-pond. This water brought with it sulphuretted hydrogen, driving the men out of the shaft about every hour. They were usually able to work in the shaft but three hours in a shift of twelve. To alleviate this, a three-inch pipe was connected to the air compressors, and a volume of fresh air forced into the shaft. At 1.20 A.M., June 6, a pocket of carbonic acid gas was opened, and the gas flowing into the trench, killed two men almost instantly, and overcame the foreman who went to their assistance. The foreman recovered in a day or two. The compressor was running at the time, and it is estimated that between seven hundred and eight hundred cubic feet of air was pumped

a cut-off to the escaping air.

An extra payment for rapid progress was made, similar to that alluded to in the description of Section 10.

The air pressure used has varied from thirteen pounds per square inch above the atmosphere at low tide to eighteen pounds at high tide.

The air pumped has been approximately as follows: —

Maximum in 24 hours,	680,000 cub. feet.
Minimum " "	160,000 " "
Average " "	300,000 " "

The excavated material is used to fill Tuft's Mill Pond.

Section 26 (Contract Work), Charlestown and Somerville.

Location. — From a point in Tuft's mill pond, about 250 feet south-westerly from Arlington Avenue and about 40 feet east of Alford Street, through the proposed Charlestown playground, across Main Street, through Cambridge Street to the tracks of the Boston & Maine railroad, and under them to Roland Street, through Roland Street and the McLean Asylum grounds to the Mystic Branch railroad.

Diameters of sewers and length of each size. —

6 feet 5 inches by 7 feet 2 inches,	530 feet.
5 feet 9 inches by 6 feet 6 inches,	3,220 "

Contractor. — H. P. Nawn of Roxbury, Mass.

Contractor's Superintendent (Year ending Sept. 30, 1893.) — James D. Fallon.

Contractor's Principal Foremen (Year ending Sept. 30, 1893.) — James Cook, Patrick Foley.

State Assistants (Year ending Sept. 30, 1893)

Assistant Engineer: Frank I. Capen.

Inspectors: Edward A. Clark, Henry M. Woodward, Samuel P. McKenzie, James E. Coyne, James J. Conway, Michael F. Garra.

Transitmen: Principals — C. Barton Pratt, Wm. W. Lewis, Frank C. Shepherd.
" Assistants — R. LeFrancis, Wm. M. Stodder, Daniel J. Sullivan, Harry L. Ward.

Trench and Tunnel.

	Including 48 feet of the Larger Sewer.	Larger Sewer.	Smaller Sewer.
Length completed of trench excavation, feet,	1,722.00	-	-
Length completed of tunnel excavation, feet,	-	482.00	1,546.00
Average depth of trench excavation to bottom of underdrain, feet,	23.50	-	-
Greatest depth of trench excavation to bottom of underdrain, feet,	29.00	-	-
Average width top of trench, feet,	9.50	-	-

Trench and Tunnel — Concluded.

	Including 48 feet of the Larger Sewer.	Larger Sewer.	Smaller Sewer.
Average width bottom of trench, feet,	8.00	-	-
Average depth from surface of ground to bottom of tunnel underdrain, feet,	-	34.30	28.80
Greatest depth from surface of ground to bottom of tunnel underdrain, feet,	-	36.00	32.80
Average width of tunnel, feet,	-	10.00	9.00
Volume of trench excavation per linear foot, cubic yards,	7.6	-	-
Volume of tunnel excavation per linear foot, cubic yards,	-	3.7	2.5
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc.,	$11 00	-	-
Approximate cost of tunnel excavation per linear foot, including excavation and refilling below masonry, sheeting left in, backfilling, etc.,	-	$14 00	$11 00

Character of Earth Excavation. — For 150 feet in tunnel, clay; next 1,000 feet, very hard mixture of sand and gravel; next 300 feet, sand and gravel down to springing line, with sandy clay below; next 200 feet, sand and gravel with slate rock in the bottom; remaining 2,100 feet, vein of fine sand on top about three feet deep, with clay below.

Masonry.

Contract price: —
- Brick-work, American cement mortar, per cubic yard, ... $12 25
- Brick-work, Portland cement mortar, per cubic yard, ... 14 00
- Concrete, American cement mortar, per cubic yard, ... 5 00
- Concrete, Portland cement mortar, per cubic yard, ... 6 00

Diameters of underdrain laid, and length of each size: —
- 4-inch, ... 65 feet.
- 6-inch, ... 2,102 "
- 8-inch, ... 1,034 "
- 10-inch, ... 538 "

Approximate cost of masonry per linear foot, including underdrain, etc.: —
- Trench, ... $8 00
- Tunnel (larger sewer), ... 14 00
- Tunnel (smaller sewer), ... 10 00

Length of masonry completed: —
- Trench, ... 1,674 feet.
- Tunnel (larger sewer), ... 482 "
- Tunnel (smaller sewer), ... 1,546 "

Masonry begun in trench, May 4, 1892; finished, March 23, 1893.

Masonry begun in tunnel, June 1, 1892; finished, April 11, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items, $23.00.

NOTE. — The information regarding Section 26 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Operations have been carried on from five openings, one open cut and four tunnel shafts. The open cut was continued from last year's work for a distance of eleven hundred feet, by means of a trench machine. The ordinary progress per week was about sixty-four feet. During the months of January and February no work was done in the trench for a week or so at a time. A No. 5 pulsometer was used from a pump well in this trench, and its estimated maximum work in any twenty-four hours was 125,000 gallons. The tunnel work proceeded as follows: Drifting was continued from the shaft near Spice Street toward the Eastern railroad until about November 1, when it was abandoned and work was continued from a shaft on the northerly side of the railroad until the headings met Dec. 22. A shaft was started October 3 near the corner of Cutter & Cutter's trunk factory on the southerly side of the railroad, from which headings progressed in both directions. The headings met under the railroad January 26. A heading was started opposite the works of the Crosby Steam Gauge & Valve Co. on February 24, and on March 13 met the one from the preceding shaft. A boom derrick was used at each tunnel shaft. The total extent of the tunnel work this year was one thousand and fifty-seven feet. The ordinary progress per week was about twelve feet in each heading, and the work proceeded without cessation. A five-inch Knowles pump was employed at each tunnel shaft. The estimated maximum amount of pumping done from the tunnel in any twenty-four hours was 60,000 gallons.

Foundation. — The bottom of the trench was excavated to fit the bottom of the sewer for nearly all the way through Roland Street and across the Asylum grounds. The foundation was also made in this way in Cambridge Street and for about two hundred feet of the distance under the Boston & Maine railroad tracks.

Miscellaneous. — The entire backfilling over the sewer tunnel under the Boston & Maine railroad was done with Portland concrete. The backfilling of the open cut was done with clay, — the material excavated. All surplus earth as far as the railroad crossing on Cambridge Street was deposited as filling in Tuft's Mill Pond. That from the railroad to the McLean Asylum grounds was placed on adjoining land. Through the Asylum grounds it was left within the taking lines.

PART OF SECTIONS 26 AND 27 (DAY WORK), SOMERVILLE.

Location. — From the easterly side of, and across, the Mystic Branch railroad, through the McLean Asylum grounds, under the Boston & Lowell railroad and private land to the corner of Joy and Poplar Streets.

Length of section, ... 950 feet.

Diameters of sewer: —

5 feet 9 inches by 6 feet 6 inches.

Assistants (Year ending Sept. 30, 1893.)

Assistant Engineer: Frank I. Capen.
Foremen: Patrick McCarthy, George F. Greenlaw.
Transitmen: Principals — C. Barton Pratt, Wm. W. Lewis, Frank C. Shepherd.
" Assistants — Harry L. Ward, Daniel J. Sullivan, Wm. M. Stodder.

Tunnel Excavation.

Length completed, ...	950.00 feet.
Average depth from surface of ground to bottom of underdrain, . .	35.00 "
Greatest depth from surface of ground to bottom of underdrain, . .	38.00 "
Average width of tunnel, ...	7.50 "

Cubic yards excavation per linear foot, 2.00.
Approximate cost of excavation per linear foot, $13.00.

Character of Excavation. — Mainly slate and indurated clay. About 225 feet under and on each side of Boston & Maine railroad was rock, hard enough to stand without much timbering. Timber was constantly required the rest of way. Blasting was necessary from Mystic Branch railroad to Asylum Avenue.

Masonry.

Length of 4-inch diameter underdrain laid, ...	950 feet.
Length of masonry completed, ...	950 "

Approximate cost of masonry per linear foot, $8.00.
Masonry begun, April 8, 1892; finished, March 7, 1893.
Approximate cost of this work per linear foot, tunnel and masonry, including labor, material and inspection, $21.00.

NOTE. — The information regarding part of Sections 26 and 27 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation, etc. — Drifts extended from two shafts. That from the shaft at a point about eighty feet west of Asylum Avenue was continued from last year. A new shaft was started Oct. 6, 1892. A hoisting apparatus called an incline was used at each shaft. The drift from the westerly shaft extended fourteen feet east. From the other shaft the drift extended two hundred and one feet west and one hundred and seventy-six feet east. A two-inch piston pump was used at each shaft to assist in taking care of the ground-water, the maximum pumping done in any twenty-four hours being about twenty-five thousand gallons. The ordinary

progress per week in two headings was about thirty feet. There was a shutdown of work from Sept. 30 to Oct. 15, 1892, in the shaft west of Asylum Avenue, due to flooding the tunnel by the bursting of a sewer in Poplar Street, near the work of McGovern & Kitch, contractors on Section 27.

Section 27 (Contract Work), Somerville and Cambridge.

Location. — From the corner of Joy and Poplar Streets, through Poplar Street to and across Somerville Avenue, land of North Packing and Provision Company, to and through Medford Street and to and across the Fitchburg railroad tracks; thence by way of Warren, Cambridge and Portland Streets to near Binney Street.

Diameters of sewers and length of each size: —

5 feet 9 inches by 6 feet 6 inches, ... 770 feet.
5 feet 2 inches by 5 feet 9 inches, ... 3,556 "

Contractors (original). — McGovern & Kitch of Lancaster, Penn.

Contractors' Superintendent (Year ending Sept. 30, 1893.) — Davis Kitch (a member of the above-mentioned firm.)

Contractors' Principal Foremen (Year ending Sept. 30, 1893.) — James Carter, William Dwyer.

State Assistants (Year ending Sept. 30, 1893)

Assistant Engineer: Frank I. Capen.
Inspectors: George F. Greenlaw, Frank M. Sherman, John D. Collins.
Transitmen: Principals — Wm. W. Lewis, Frank C. Shepherd, Warren A. Rogers, Hartley L. White.
" Assistants — Harry L. Ward, Elwyn W. Stebbins, Wm. H. Boardman, Jr.

Trench and Tunnel.

	Larger Sewer.	Smaller Sewer.
Length completed of trench excavation, feet, ...	770.00	2,511.00
Length completed of tunnel excavation, feet, ...	-	718.00
Average depth of trench excavation to bottom of underdrain, feet, .	24.40	22.90
Greatest depth of trench excavation to bottom of underdrain, feet, .	26.40	24.80
Average width top of trench, feet, ...	9.00	8.80
Average width bottom of trench, feet, ...	9.00	8.50
Average depth from surface of ground to bottom of tunnel underdrain, feet, ...	-	24.90
Greatest depth from surface of ground to bottom of tunnel underdrain, feet, ...	-	25.30
Average width of tunnel excavation, feet, ...	-	6.40
Volume of trench excavation per linear foot, cubic yards, . . .	8.1	7.3
Volume of tunnel excavation per linear foot, cubic yards, . . .	-	2.06

Character of Earth Excavation. — One foot of street filling at the surface, then one or two feet of loam or peat, a five-foot vein of fine sand containing water, clay to grade.

Masonry.

Diameters of underdrain laid, and length of each size: —

6-inch,	1,173 feet.
8-inch,	2,208 "
10-inch,	314 "
12-inch,	267 "

Length of masonry completed: —

Larger sewer (trench),	770 feet.
Smaller sewer (trench),	2,492 "
Smaller sewer (tunnel),	698 "

Masonry was begun in trench, June 29, 1892, and is now (September 30) in progress.
Masonry was begun in tunnel, April 12, 1893, and is now (September 30) in progress.

NOTE. — The information regarding section 27 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Re-letting, etc. — On account of the unnecessary and unreasonable delay of Messrs. McGovern & Kitch in carrying on the work it was taken from them on October 15. They had then completed on Poplar Street from its intersection with Joy Street (the beginning of the section) to Maple Street, about six hundred feet of trench and five hundred and twenty-three feet of brick-work; in North's yard near Somerville Avenue, about eighty-four feet of trench and forty-three feet of brick-work; on Portland Street they had completed towards Binney Street from the corner of Cambridge and Portland Streets, two hundred and forty feet of trench and one hundred and fifty-five feet of brick-work. The State continued the work as it had been started, and at the same time re-let a part of this section to the Metropolitan Construction Company. This part included from a point twenty feet south of the Fitchburg railroad to the completed work at the corner of Cambridge and Portland Streets (a distance of one thousand four hundred and fifty-one feet), and also from a point near the Hook and Ladder house on Portland Street, about five hundred feet south of Cambridge Street, to the end of the section, a distance of two thousand one hundred and sixty feet. The State work was completed April 20, 1893. The Metropolitan Construction Company began work on Portland Street, Nov. 15, 1892.

Excavation. — Two trench machines, a mining hoist and three inclines have been used.

Character of Opening.	Date of Beginning.	Begun at or continued from.	Points of Ending.	Extent.	Ordinary Progress per Week.
				Feet.	Feet.
Open cut, . . .	June 23, 1892,	Corner Linwood and Poplar Streets, ...	North's Yard, at Somerville Avenue, ...	145	9
Open cut, . . .	June 27, 1892,	North's Yard, at Somerville Avenue, ...	Fitchburg Railroad tracks, ...	316	46
Tunnel, 1 heading, .	April, 1893, .	In Medford Street, about 20 feet south of Fitchburg Railroad tracks.	Twenty feet north of Fitchburg Railroad tracks, meeting open trench.	99	22
Open cut, . . .	June 5, 1893,	Medford Street, near Ward Street, ...	South Street, ...	289	64
Tunnel, 1 heading, .	June 5, 1893,	Medford Street, near Warren Street, ...	At tunnel under Fitchburg Railroad tracks, . . .	237	22
Tunnel, 1 heading, .	July 22, 1893,	Medford Street, at South Street, ...	Near Warren Street, ...	147	22
Tunnel, 2 headings,	Aug 31, 1893,	Warren Street, between Porter and Jefferson Streets, .	East, Porter Street; west, Jefferson Street, . . .	166	45
Open cut, . . .	Sept. 9, 1892,	Corner Cambridge and Portland Streets, ...	Ne 60 feet in front of hook	1,433	96
Tunnel, 1 heading, .	Dec. 1, 1892,	In front of hook and ladder house, Portland Street, .	In ouse, Portland Street, .	60	12
Open cut, . . .	July 6, 1893,	Corner Cambridge and Portland Streets, ...	Warren Street, ...	283	30

The pumping plant for the removal of ground-water has been employed as follows: on Portland and Warren streets, in the open cuts, a six-inch centrifugal pump used at pump wells; in the tunnels, a three-inch pulsometer used, except under the Fitchburg railroad, where a two-inch steam pump was used. In North's Yard and on Poplar Street a six-inch centrifugal pump and a two and one-half inch ejector were used at pump wells. It is estimated that during the time of the maximum pumping four hundred thousand gallons of ground-water were removed in twenty-four hours. There were interruptions to the work in September and October, 1892, through the bursting of local sewers, etc., as alluded to further on. During January, February and March no work was done in Portland Street on account of the extreme cold.

Foundation. — All but the first sixty feet of the trench rests on a clay bottom, which was shaped to fit the invert of the sewer. The exception noted had a rock bottom, which was excavated to a depth of about six or eight inches below the bottom of the brick-work and replaced by concrete.

Difficulties, Accidents. — The Metropolitan sewer has been built under local sewers at Linwood Street and Somerville Avenue, alongside the Poplar Street local sewer, under the Fitchburg railroad tracks, under local sewers at Cambridge Street, and alongside the local sewer in Portland Street. The sewer passes also under the West End Street railway tracks at Somerville Avenue and Cambridge Street. In each case where the Metropolitan sewer passed under local sewers a solid concrete pier was built between the two. Under the Fitchburg railroad tracks the arch of the sewer was backfilled with Portland concrete.

On Sept. 30, 1892, and again on Feb. 15, 1893, the Poplar Street local sewer burst flooding the Metropolitan trench. The local sewer was replaced for a time by an iron pipe, and was afterward rebuilt by the State. On Portland Street rain and ground-water filled the contractors' trench, Oct. 8, 1892. April 20, 1893, there was a settling of Portland Street, near Dow's Soap Works. The local sewer and one of its man-holes was broken down. The injured structures were rebuilt by the contractors.

Several buildings have settled about quarter of an inch. The house on the north-west corner of Somerville Avenue and Poplar Street settled about four inches, cracking the foundation badly. The houses were repaired either by the State or the contractors,

and the one on the corner of Somerville Avenue and Poplar Street was raised and given a new foundation.

On May 15, near Dow's Soap Works, the centres were struck before the arch was sufficiently loaded. The clay on the sides pressed the masonry in and caused it to fail for a distance of nineteen feet, beyond which a crack showed for seventeen feet. The injured masonry was taken up and relaid by the contractors.

There have been two instances where a man in the trench has sustained temporary injury by being struck by a bucket. In one case the engineer let the drum unwind before the bucket was locked, and in the other the bucket was accidentally knocked over the edge of the trench.

Miscellaneous. — The surplus earth has been used for filling on adjacent lands. At the end of the section, near Binney Street, a chamber for a double float regulator was built upon the Metropolitan sewer. Between Somerville Avenue and Medford Street the sewer passes through land owned by the North Packing and Provision Company. After the sewer was built this company decided to erect a building over it and began to drive pile-work foundation. To protect the sewer four concrete piers, twenty feet apart, were built over it to a height of eight feet six inches above the crown of the arch at places where the pile bents would come. The top of each pier was about five feet square, and increased in size to the hard clay bottom, which was at the springing line of the sewer.

Section 28, Cambridge.

Location. — From a point in Portland Street about fifty feet north of Binney Street, through Portland and Albany Streets, across Front Street and through Albany Street extension to Waverly Street at Allston Street; thence through Waverly Street to Chestnut Street.

Length of section, ... 6,500 feet.

Diameters of sewer: —

4 feet by 4 feet 6 inches.

Contractors. — John L. Reardon & Company of Brighton, Mass.

Contractors' Superintendent. — Thomas J. Young, a member of the above-mentioned firm.

Contractors' Principal Foremen. — Michael Stapleton, James McManus.

State Assistants.

Assistant Engineer: Frank I. Capen.

Inspectors: Caleb Kimball, Frank M. Sherman.

Transitmen: Principals — Wm. W. Lewis, Frank C. Shepherd, Warren A. Rogers, Hartley L. White.

Transitmen: Assistants — Harry L. Ward, Elwyn W. Stebbins, William H. Boardman, Jr.

Trench and Tunnel.

Length completed of trench excavation,	5,608.00 feet.
Length completed of tunnel excavation,	40.00 "
Average depth of trench excavation to bottom of underdrain,	17.90 "
Greatest depth of trench excavation to bottom of underdrain,	22.00 "
Average width top of trench,	8.50 "
Average width bottom of trench,	7.50 "

Cubic yards trench excavation per linear foot, 5.30.

Approximate cost of trench and tunnel per linear foot to date (September 30), including excavation and refilling below masonry, backfilling, etc., to date (September 30), $7.00.

Character of Earth Excavation. — For the first 1,900 feet, as far as Main Street, about ten feet of sand and gravel, with clay below to grade; from thence for about seven hundred feet, to a point four hundred feet north of Front Street, miscellaneous filling, and peat below to the bottom of the sewer; from three hundred feet south of Front Street for about 1,900 feet to near Erie Street, ten feet of peat overlying sand to the bottom of the sewer; from thence to the end of the section, filling, peat, loam, and sand to grade, — there being clay in the bottom for a distance of about 145 feet near the end of the section.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard,	$12 15
Brick-work, Portland cement mortar, per cubic yard,	13 75
Concrete, American cement mortar, per cubic yard,	5 00
Concrete, Portland cement mortar, per cubic yard,	6 50
Diameters of underdrain laid, and length of each size: —	
8-inch,	1,703 feet.
10-inch,	2,338 "
12-inch,	1,563 "
Approximate cost of masonry per linear foot, including underdrain, etc.: —	
Trench,	$5 66
Tunnel,	5 06
Length completed, trench,	5,489 feet.
Length completed, tunnel,	29 "

Masonry was begun in trench Nov. 29, 1892, and is now (September 30) in progress.

Masonry was begun in tunnel Sept. 27, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items to date (September 30), $13.00.

Excavation. — The excavation operations have proceeded from two open cuts and from a tunnel shaft. The first open cut was started Nov. 14, 1892, at a point about three hundred feet south of Front Street, and continued by means of a trench machine to the end of the section at Waverly Street, a distance of about three thousand one hundred and thirty-one feet. The ordinary progress per week was about one hundred and ninety-two feet. When the end of the work was reached on this opening the trench machine was moved to a point about sixty-five feet from the beginning of the section, at the corner of Portland and Bristol streets, and an opening was started there on May 10, 1893. Work from this latter opening has progressed a distance of about two thousand

north of Front Street; seventy-four feet being left at Main Street for tunnelling. The average progress per week has been about one hundred and forty-four feet. A tunnel shaft was started September 18 on the north side of Main Street, and has proceeded under that street for a distance of about forty feet. An incline is used for hoisting at this shaft. Pump wells have been established every eight hundred feet. On Portland Street, from Bristol to Hampshire Streets, the pumping of ground-water has been done by a four-inch Webber centrifugal pump. A six-inch Webber pump has been used elsewhere, supplemented along the marsh from Front to Erie streets by the four-inch pump. The maximum amount of water pumped in any twenty-four hours has been about 550,000 gallons. The excavation work has progressed continuously.

Foundation. — The bottom of the trench was shaped to fit the invert of the sewer from the corner of Portland and Bristol streets to the corner of Portland and Main streets, a distance of about one thousand nine hundred feet, and for a distance of about one hundred and forty-five feet near the end of the section, on Waverly Street. For a distance of about four hundred and thirty-four feet, from a point about eighty feet south of Main Street and running towards Front Street, excavation to an average depth of about fourteen inches was made below the bottom of the brick-work and the intervening space filled with gravel.

Miscellaneous. — The Metropolitan sewer has been built under local sewers at Hampshire Street, Broadway; Harvard, Washington, Waverly and Allston streets and Putnam Avenue. The intervening space between the two sewers in each case was filled with concrete. The sewer crosses under the West End railroad tracks at Hampshire Street and Broadway. All this work of crossing under sewers and railroad tracks has been done without especial difficulty. The surplus earth from the sewer trench has been deposited in adjacent lowlands.

Section 29, Cambridge.

Location. — From a point in Waverly Street, near the north corner of Chestnut Street, through Waverly Street, private way, Granite Street, private land, River, Blackstone, Albro and Ampere Streets to Western Avenue.

Diameters of sewers and length of each size: —

4 feet by 4 feet 6 inches,	1,740 feet.
3 feet 8 inches by 4 feet 2 inches,	1,321 "
3 feet 6 inches by 4 feet,	2,093 "

Contractors. — Lindsay & Cudmore of Somerville, Mass. The two members of this firm acted as their own superintendents.
Contractors' Principal Foreman. — John Doherty.

State Assistants.

Assistant Engineer: Frank I. Capen.
Inspectors: Samuel Corning, Caleb Kimball, Frank M. Sherman.
Transitmen: Principals — C. Barton Pratt, Frank C. Shepherd.
" Assistants — Wm. M. Stodder, Edward I. Marvell.

Trench.

	4 feet by 4 feet 6 inches sewer.	3 feet 8 inches by 4 feet 2 inches sewer.	3 feet 6 inches by 4 feet sewer.
Length completed, feet,	1,740.00	1,321.00	265.00
Average depth of excavation to bottom of underdrain, feet,	16.20	12.90	-
Average depth of excavation to bottom of pile cap, feet,	-	-	14.55
Greatest depth of excavation to bottom of underdrain, feet,	21.00	17.50	-
Greatest depth of excavation to bottom of pile-cap, feet,	-	-	16.00
Average width top of trench, feet,	9.00	7.30	7.50
Average width bottom of trench, feet,	7.00	7.30	7.50
Volume of excavation per linear foot, cubic yards,	5.06	3.50	4.04
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30),	$4 80	$3 50	$4 90

Character of Earth Excavation. — For first two thousand feet, twelve feet of sand above about five feet of wet gravel; next nine hundred feet, about five feet of peat above about five feet of sand, with gravel to the bottom of the sewer; from thence to a point about one hundred feet west from the corner of the works of the Dover Stamping Company, all peat.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	13 50
Concrete, American cement mortar, per cubic yard,	4 75
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid and length of each size: —

8-inch,	543 feet.
12-inch,	2,992 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30): —

4 feet by 4 feet 6 inches and 3 feet 8 inches by 4 feet 2 inches sewer,	$6 00
3 feet 6 inches by 4 feet (with pile foundation),	13 30

Length of masonry completed: —

4 feet by 4 feet 6 inches sewer,	1,740 feet.
3 feet 8 inches by 4 feet 2 inches,	1,321 "
3 feet 6 inches by 4 feet,	51 "

Masonry was begun, April 30, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, to date (September 30), including labor, material, inspection, and miscellaneous items, $11.00.

started at the lower end of the section on April 20, 1893. The operations from this opening have now extended a distance of about three thousand three hundred and twenty-six feet, to a point about one hundred feet west from the corner of the works of the Dover Stamping Company. The ordinary progress per week has been about one hundred and fifty feet. The only interruptions have been those caused by the tide breaking through the dyke. Pump wells have been established every six hundred feet. At the first two of these wells a six-inch centrifugal pump was used, and a six-inch and a four-inch pump has been used at each of the succeeding wells. It is estimated that the maximum amount of pumping in any twenty-four hours was about 750,000 gallons. A second opening was started September 26 at the curve, corner of Blackstone and Albro Streets, and is being worked toward the upper end of the section. An incline is being used, and the trench has been excavated a distance of about thirty feet.

Foundation. — From a point about fifty-one feet from the lower end of the section, and extending for a distance of about two hundred and eighty-three feet, the bottom of the trench was clay, which was shaped to fit the invert of the sewer. For a distance of eighty-one feet at the foot of Pleasant Street, excavation was made to a depth of about one and one-quarter feet below sewer grade, and the space below filled with concrete. From thence a pile foundation has been used. The piles have been driven in bents of three each, the bents being four feet apart. The tops have been covered with an eight-inch by ten-inch cap surmounted by a three-inch platform. The piles have been from fifteen to twenty feet in length.

Difficulties. — The Metropolitan sewer has been built under Cambridge sewers at Pearl and Pleasant Streets. At the first of these points a solid concrete pier was built occupying all the space between the two sewers, and at the latter point the arch of the Metropolitan sewer for a distance of seven feet each side of the local sewer was built of solid Portland concrete. The Metropolitan sewer was here widened eight inches at the springing line and flattened one foot three inches at the crown.

Miscellaneous. — The surplus earth for the first eleven hundred feet was used to fill in land owned by Edmund Reardon, and that gained for the rest of the way has been levelled off along the marsh, over the sewer.

SECTION 30, CAMBRIDGE.

Location. — From Western Avenue, at the end of Ampere Street across Western Avenue and through private land to DeWolfe Street; through DeWolfe and Dyke Streets and private land to and across Dunster Street, through private land and across Boylston to Eliot Street; and through Eliot Street, Eliot Square and Mt. Auburn Street to Lowell Street.

Diameters of sewers and length of each size: —

3 feet 5 inches by 3 feet 8 inches, ... 2,190 feet.
2 feet 10 inches by 3 feet; 2 feet 8 inches by 2 feet 10 inches, . . 3,022 "
2 feet 3 inches by 2 feet 4 inches, ... 1,813 "

Contractors. — Jones & Meehan of Jamaica Plain, Mass.

Contractors' Superintendent. — Michael Meehan, a member of the above-named firm.

Contractors' Principal Foremen. — Peter Dolan, John Monahan.

State Assistants.

Assistant Engineer: Frank I. Capen.
Inspectors: George F. Greenlaw, Warren A. Rogers, Hadson B. Damon.
Transitmen: Principals — C. Barton Pratt, Frank C. Shepherd.
" Assistants — Wm. M. Stodder, Edward I. Marvell.

Trench.

	Largest Sewer.	Two Smaller Sewers.	Smallest Sewer.
Length completed, feet, ...	2,024.00	2,659.00	872.00
Average depth of excavation to bottom of underdrain, feet,	13.80	15.60	-
Average depth of excavation to bottom of pile cap, feet, .	-	-	12.70
Greatest depth of excavation to bottom of underdrain, feet,	18.80	21.80	-
Greatest depth of excavation to bottom of pile cap, feet, .	-	-	17.60
Average width top of trench, feet, ...	6.00	6.25	5.20
Average width bottom of trench, feet, ...	6.00	6.50	5.20
Volume of excavation per linear foot, cubic yards, . .	3.07	3.69	2.45
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, back-filling, etc., to date (September 30), ...	$4 00	$4 50	$4 50

Character of Earth Excavation. — From Western Avenue to corner of DeWolfe and Dyke Streets, a distance of about 1,900 feet, 1 foot of loam or gravel, then clay to grade; from thence to about one hundred feet east of Boylston Street, gravel, peat and sand — the peat sometimes running below the springing line of the sewer; for about 150 feet, filling with peat below; from thence for four hundred feet to Eliot Square, sand and gravel to grade; for two hundred feet, gravel filling with peat below; thence to one hundred feet west of Hawthorn Street, sand and gravel; from thence on, gravel filling and peat running below grade.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard, ... $13 00
Brick-work, Portland cement mortar, per cubic yard, ... 15 00
Concrete, American cement mortar, per cubic yard, ... 5 00
Concrete, Portland cement mortar, per cubic yard, ... 7 00

6-inch,	. . . .	1,978 feet.
8-inch,	. . . .	3,110 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30): —

Largest sewer,	. . . .	$5 10
Two smaller sewers,	. . . .	4 80
Smallest sewer,	. . . .	5 70

Lengths of masonry completed: —

Largest sewer,	. . . .	2,001 feet.
Two smaller sewers,	. . . .	2,495 "
Smallest sewer,	. . . .	476 "

Masonry was begun June 26, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items, to date (September 30), $10.00.

Excavation. — Two single track trench machines have been used. The excavation has been worked from three open cuts as follows: One was begun at the lower end of the section at Western Avenue on June 19, and has advanced a distance of about nineteen hundred and forty feet to the corner of Dyke and DeWolfe Streets, — the ordinary progress per week being about two hundred and five feet. A second opening was commenced July 3 on Mount Auburn Street, near the Police Court building, and operations from this opening have progressed for a distance of about two thousand three hundred and seventy-two feet in this street to Marsh Court, at the ordinary rate per week of about one hundred and ninety-five feet. The third and last opening was begun at the corner of Dyke and Plympton Streets, August 22. Work has progressed at the ordinary rate per week of about one hundred and eighty feet for a distance of about one thousand two hundred and forty feet to Boylston Street.

A pump well was placed at Western Avenue and another at the corner of Dyke and Plympton Streets, with a four-inch Webber centrifugal pump at each. There have also been two pump wells on Mount Auburn Street, with a six-inch Webber pump used at each in succession. The excavation work has progressed continuously.

Foundation. — The clay bottom of the trench has been so dug as to fit the invert of the sewer from the lower end of the section at Western Avenue to the corner of DeWolfe and Dyke Streets, a distance of about one thousand nine hundred and forty feet. For a distance of about seventy-three feet in Eliot Square near the engine house, and for a distance of forty feet, from a point on Mount Auburn Street one hundred feet west of Hawthorn Street, the earth has been removed to a depth of about two feet below sewer

grade and the space filled with American concrete. Between Dunster and Boylston Streets, for a distance of about ninety-five feet, excavation was made to a depth of three feet below sewer grade and the space filled with gravel. Pile driving was resorted to from a point about fifty-nine feet east of Boylston Street to the west side of that street. These piles, twelve feet in length, were driven in bents of two each — the bents being four feet apart and covered with eight-inch by eight-inch caps surmounted by a three-inch platform. A pile foundation has also been used on Mount Auburn Street from a point about one hundred and fifty feet west of Hawthorn Street to where work is going on at the present time. These are forty-foot piles, and the details in regard to bents, capping and platform are the same as in the case before mentioned.

Miscellaneous. — The Metropolitan sewer has passed under several local sewers. Solid concrete piers have been built to occupy all the space between the two in each case. At Western Avenue and Plympton Street, where local sewers were met, the cross-section of the Metropolitan sewer was changed to iron pipes three feet six inches and three feet in diameter respectively, with a reducer five feet in length at each end, the local sewers being so reconstructed that their flows could pass both over and under the Metropolitan sewer. At Willard Street the sewer line was moved ten inches to the left to avoid a tide-gate man-hole in the local sewer. The surplus earth gained from the trench has been used for filling adjacent land.

Section 37, East Boston.

Location. — From a point in Chelsea Street, about two hundred feet from Chelsea Creek bridge, to Prescott Street and in that and Bremen Street to a point about three hundred feet beyond Brooks Street.

Diameters of sewers and length of each size: —

3 feet 4 inches by 3 feet 9 inches,	472 feet.
3 feet by 3 feet 5 inches,	4,410 "

Contractor. — John Sheehan of Lynn, Mass.

Contractor's Superintendents. — Wm. Hall, M. F. Garra (from June 12 to August 30).

Contractor's Principal Foremen: —

Trench — Michael Kiernan, Jeremiah Barry.
Tunnel — J. N. Reesby.

State Assistants.

Assistant Engineer: Seth Peterson.
Inspectors: M. F. Garra (to June 12), J. J. Conway.
Transitmen: Principal — Fred Brett.
" Assistant — Thomas T. Cass.

	Larger Sewer.	Smaller Sewer.
Length completed of trench excavation, feet,	136.00	404.00
Length completed of tunnel excavation, feet,	186.00	1,161.00
Average depth of trench excavation to bottom of underdrain, feet,	28.50	31.50
Greatest depth of trench excavation to bottom of underdrain, feet,	29.00	32.00
Average width top of trench, feet,	8.00	6.00
Average width bottom of trench, feet,	7.00	6.00
Average depth from surface of ground to bottom of tunnel underdrain, feet,	30.00	31.20
Greatest depth from surface of ground to bottom of tunnel underdrain, feet,	31.00	32.50
Average width of tunnel,	4.70	4.40
Volume of trench excavation per linear foot, cubic yards,	8.3	8.0
Volume of tunnel excavation per linear foot, cubic yards,	1.2	1.0
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30),	$7 00	$7 00
Approximate cost of tunnel excavation per linear foot, including excavation and refilling below masonry, backfilling, etc., to date (September 30),	6 00	5 50

Character of Earth Excavation. — Street surfacing and clay, except a pocket of sand and gravel near Curtis Street.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 90
Brick-work, Portland cement mortar, per cubic yard,	15 00
Concrete, American cement mortar, per cubic yard,	5 50
Concrete, Portland cement mortar, per cubic yard,	6 80

Diameters of underdrain laid, and length of each size: —

6-inch,	744 feet.
8-inch,	222 "
10-inch,	107 "
12-inch,	200 "

Approximate cost of masonry per linear foot of trench and tunnel, including underdrain, etc., to date (September 30), $5.00.

Length of masonry completed: —

Trench,	390 feet.
Tunnel,	984 "

Masonry was begun in tunnel, March 27, 1898, and is now (September 30) in progress.

Masonry was begun in trench, July 27, 1898, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items to date (September 30), $12.00.

Excavation.

Character of Opening.	Point of Beginning.	Points of Ending.	Extent, feet.	Ordinary Progress per Week. feet.
Tunnel, .	Lower end of section, .	186 feet toward Curtis St.,	186	42
Tunnel,* .	Curtis St., ...	130 feet north of Curtis St. and 410 feet south of the same street, . .	540	64
Tunnel, .	430 feet south of Curtis St.,	30 feet north of shaft and about 170 feet south of shaft, ...	204	42
Tunnel, .	Nearly opposite Glendon Place.	120 feet north and the same distance south, .	240	84
Tunnel, .	In front of Maverick Oil Works.	180 feet north of shaft and the same distance south,	356	84
Tunnel, .	About the middle of Eagle Square.	170 feet north of shaft and 160 feet south of same, .	331	84
Tunnel, .	Just north of Saratoga St.,	10 feet north and 10 feet south, ...	20	-

* Changed to open cut.

Two headings were run from all but the first shaft. A trench machine was used on the open cut, and material excavated from the tunnel shafts was handled with derricks and wheelbarrows. The tunnelling was secured by timber sets. A six-inch Andrews pump has been placed about three hundred feet south of Curtis Street, and a pulsometer and hand pump have been used in each tunnel shaft. The ground-water in each tunnel shaft could have been taken care of, as far as pumping was concerned, with a hand pump alone, except in the case of the shaft south of Curtis Street. At this shaft and the open cut connected with the same pump, the yield of ground-water was estimated to be 1,400,000 gallons per twenty-four hours. The work has progressed with practically no shut-downs.

Foundation. — The bottom of the trench has been shaped to fit the invert of the sewer all the way except about five hundred feet near Curtis Street and about two hundred feet between Eagle and Saratoga streets. Near Curtis Street the foundation was in loose, wet sand and gravel. Between Eagle and Saratoga streets the underlying sand will be removed to a depth of about six inches below the bottom of the masonry and refilled with gravel.

Difficulties. — The only serious obstacles came from the water in the gravel stratum near Curtis Street. The upper part of this gravel stratum was saturated with oil which soaked through the ground from the oil works near by. Gas evaporated from this which was quite disagreeable in the bottom of the trench. To

Portland cement mortar, and from a point about three hundred feet south of Curtis Street to that street the arch was covered with an extra coat of plaster of the same, about one-half inch in thickness.

Miscellaneous. — The surplus earth gained by the sewer operations has been used for filling adjacent low lands.

Section 40, Everett and Malden.

Location. — From near Waters Avenue in Everett, along the westerly side of the Saugus Branch railroad to Middlesex Street in Malden, and in this street to Charles Street.

Length of section, ... 6,252 feet.

Diameters of sewer, 3 feet 9 inches by 4 feet 1 inch.

Contractors. — R. A. Malone & Sons of Philadelphia, Penn.

Contractors' Superintendent (Year ending Sept. 30, 1893). — Michael Tallant.

Contractors' Principal Foreman (Year ending Sept. 30, 1893). — Michael Stapleton.

State Assistants (Year ending Sept. 30, 1893).

Inspectors: Caleb Kimball, James E. Coyne.

Transitman: Principal — Paul W. Rowell.

" Assistants — Fred Brett, George P. Chase, George R. Winslow.

Trench.

Length completed,	6,252.00	feet.
Average depth of excavation to bottom of underdrain,	16.00	"
Greatest depth of excavation to bottom of underdrain,	24.00	"
Average width top of trench,	7.80	"
Average width bottom of trench,	7.50	"

Cubic yards excavation per linear foot, 4.10.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $5.50.

Character of Earth Excavation. — On the marsh, generally through four feet of peat and four or five feet of sand to firm clay; in the vicinity of Bell Rock Station, through sand, gravel and clay; at works of Hub Cement Company, gravel, sand and ledge; upper seven hundred feet of section, sand and silt.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	13 75
Concrete, American cement mortar, per cubic yard,	5 75
Concrete, Portland cement mortar, per cubic yard,	7 00

Diameters of underdrain laid and length of each size: —

6-inch,	825	feet.
8-inch,	1,622	"
10-inch,	2,924	"
12-inch,	842	"

Approximate cost of masonry per linear foot, including underdrain, etc., $7.00.
Length completed, ... 6,252 feet.

Masonry begun, Oct. 5, 1891; finished, April 1, 1893.

Approximate cost of section per linear foot of trench and masonry, including labor, material, inspection, extra payment to contractor and miscellaneous items, $14 00.

NOTE. — The information regarding Section 40 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Operations were carried on from two openings, (No. 1) being continued from last year's work at a point opposite the paint factory of Wadsworth, Howland & Co., to where the creek crosses the sewer about four hundred feet south of Middlesex Street. The other opening (No. 2) was started Nov. 5, 1892, at the corner of Charles and Middlesex Streets, Malden, and extended to the creek crossing just mentioned. A trench machine was used for all but about four hundred feet of the trench at the upper end of the section at which place a derrick was used. A six-inch pump opposite the factory of Wadsworth, Howland & Co., took care of the ground-water in opening No. 1; at the time of its maximum service pumping an estimated quantity of 300,000 gallons in twenty-four hours. A similar pump was used at opening No. 2, and during the time of its greatest use pumped an estimated quantity of 600,000 gallons in twenty-four hours. The ordinary progress per week at each opening was as follows: No. 1, seventy-eight linear feet; No. 2, forty linear feet. There was a shut-down from Feb. 24 to March 11, 1893.

Foundation. — The bottom of the trench was dug to fit the bottom of the sewer for a distance of about nine hundred feet, extending from a point opposite the factory of the Hub Cement Co. to a point just south of the creek crossing. The trench was excavated to an average depth of about five feet below the bottom of the masonry and refilled with gravel from the southerly crossing of the old bed of Malden River to a point opposite the factory of the Hub Cement Co.

Difficulties. — The sewer passes under the creek near the upper end of the section, in close proximity to the railroad. On Dec. 3, 1893, the tide broke down the dams there used. The sewer at that point is heavily reinforced with Portland concrete.

Miscellaneous. — On the marsh an embankment was built over the sewer to a height of about two feet from the natural surface.

SECTION 41 (CONTRACT WORK), MALDEN AND MELROSE.

Location. — From a point near the junction of Charles and Middlesex Streets, Malden, through Middlesex and Dartmouth Streets to near the yard of the Cochrane Worsted Mill. The work in the space intervening between this point and Mountain Avenue was done by day labor. From Mountain Avenue east of Spot Pond Brook the contract work proceeds through private and railroad land in Malden and Melrose, passing near to and in the rear of Middlesex Fells Station to Goodyear Avenue, thence across the Boston & Maine railroad and alongside the brook to Pleasant Street near Gould, through Pleasant Street to Wyoming Avenue, Melrose.

Diameters of sewers and length of each size: —

2 feet 1 inch by 3 feet 2 inches,	1,750 feet.
1 foot 10 inches by 2 feet 9 inches,	3,030 "
1 foot 8 inches by 2 feet 6 inches,	5,016 "

Contractors. — Moulton & O'Mahoney of Boston, Mass.

Contractors Superintendent (Year ending Sept 30, 1893). — Orren Trumbull.

Contractors' Principal Foreman (Year ending Sept. 30, 1893). — Louis I. Chausse.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer. Wilbur F. Goodrich.
Inspectors: Guy C. Emerson, B. L. Sykes, Ernest Girard.
Transitmen: Assistants — Edward F. Adams, George F. Clark.

Trench.

Length completed,	9,343.00 feet.
Average depth of excavation to bottom of underdrain,	13.00 "
Greatest depth of excavation to bottom of underdrain,	19.00 "
Average width top of trench,	4.50 "
Average width bottom of trench,	4.50 "

Cubic yards excavation per linear foot, 2.20.

Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30), $3.00.

Character of Earth Excavation. — Sand and gravel, ledge, boulders, filling, and very fine sand containing much water.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$14 50
Brick-work, Portland cement mortar, per cubic yard,	17 00
Concrete, American cement mortar, per cubic yard,	6 30
Concrete, Portland cement mortar, per cubic yard,	8 50

Diameters of underdrain laid and length of each size: —

4-inch,	1,213 feet.
6-inch,	2,175 "
8-inch,	3,410 "
10-inch,	174 "

Approximate cost of masonry per linear foot, including underdrain, double plastering, cheese-cloth, platform, etc., to date (September 30), $4.00.

Length of masonry completed,	9,243 feet.

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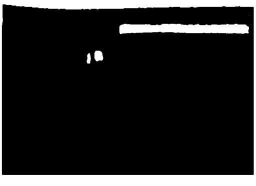


	Old Opening.	New Opening, No. 1.	New Opening, No. 2.	New Opening, No. 3.	New Opening, No. 4
Date of beginning,	July 18, 1892, ...	Nov. 11, 1892, . . .	Jan. 2, 1893, . . .	May 29, 1893, . . .	Sept. 18, 1893.
Point of beginning or continuing.	315 feet north of Clinton St., .	247 feet north of Centre St., Malden.	Northerly side of Pleasant St., Malden.	Junction of Charles and Middlesex Sts.	Centre of Pleasant St., junction of Dartmouth
Point of ending, .	Pleasant St., Melrose, about 360 feet south of Wyoming Ave.	Junction Pleasant and Middlesex Sts.	Near yard of Cochrane Worsted Mill.	247 feet north of Centre St., in Middlesex St.	Junction of Pleasant Dartmouth Sts.
Extent of work, .	6,805 feet, ...	267 feet, ...	470 feet, ...	847 feet, ...	56 feet.
Ordinary progress per week.	31 feet, ...	36 feet, ...	34 feet, ...	53 feet, ...	27 feet.

The pumping plant used in removing the ground-water has consisted of two six-inch centrifugal pumps, one being used at each of the following points: at the corner of Charles and Middlesex Streets, at the corner of Pleasant and Dartmouth streets, fifty feet north of Clinton Street, fifty feet south of Winter Street, twelve hundred feet south of Fells Station, two hundred feet south of the junction of Pleasant and Gould Streets, and at points respectively eight hundred and four hundred feet south of Wyoming Avenue on Pleasant Street. The maximum amount of ground-water pumped in twenty-four hours during the time of the greatest flow is estimated to have been about 720,000 gallons. On opening No. 2 there was a shut-down of work from Feb. 13 to April 3, 1893, on account of cold weather.

Foundation. — Quicksand was encountered as follows: in Middlesex street for a distance of eight hundred feet northerly from Charles Street, three hundred and fifteen feet north of Clinton Street to one thousand feet north of Goodyear Avenue, one thousand three hundred feet north of Goodyear Avenue to the corner of Pleasant Street and Wyoming Avenue. The fine sand has been removed to a depth of one foot below the bottom of the sewer and replaced with gravel at the following places: Two hundred feet north from the junction of Pleasant and Dartmouth Streets to the head of Dartmouth Street, and from four hundred feet south of Fells Station, sixty feet back towards the same. Piles averaging twenty-five feet in length have been driven, in bents, two feet apart on centres, with eight-inch by ten-inch caps surmounted by two-inch flooring, from a point one thousand feet north of Goodyear Avenue for a distance of three hundred feet northerly.

Difficulties. — There was a heavy flow of water at the corner of Charles and Middlesex Streets and at the corner of Pleasant and Dartmouth Streets. Malden River was crossed two hundred and fifty feet north of Centre Street in Middlesex Street, and Spot Pond Brook has been crossed at points as follows: one hundred and sixty feet south of Winter Street, Malden; four hundred feet south of Fells Station; one thousand four hundred and fifty feet north of Goodyear Avenue and four hundred and twenty feet south of Wyoming Avenue. The sewer passed under the Boston & Maine railroad near Goodyear Avenue. At all of these crossings the masonry has been increased by Portland concrete at top and bottom.

Miscellaneous. — About two thousand feet of two-inch land tile has been laid on top of platform on each side of concrete. The surplus earth from the trench has been taken by abutters.

SECTION 41 (DAY WORK), MALDEN.

Location. — From the head of Dartmouth Street, through private land, pond of Cochrane Carpet Company, private land, Cochrane Reservoir and private land to Mountain Avenue.

Length of section,	1,014 feet.
Diameters of sewers and length of each size: —	
2 feet 1 inch by 3 feet 2 inches,	314 "
1 foot 8 inches by 2 feet 6 inches,	700 "

Assistants (Year ending Sept. 30, 1893).

Assistant Engineer and Inspector: Wilbur F. Goodrich.
Foremen: B. L. Sykes.
Transitmen: Assistants — Edward F. Adams, George F. Clark.

Trench.

Length completed,	1,014.00 feet.
Average depth of excavation to bottom of concrete,	10.00 "
Greatest depth of excavation to bottom of concrete,	21.00 "
Average width top of trench,	5.50 "
Average width bottom of trench,	5.30 "

Cubic yards excavation per linear foot, 2.00.
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., $9.50.

Character of Excavation. — Gravel, reservoir sediment, sand and ledge.

Masonry.

Cost per cubic yard: —

Brick-work, Portland cement mortar, per cubic yard,	$22 50
Concrete, Portland cement mortar, per cubic yard,	5 00

Diameters of underdrain laid and length of each size: —

6-inch,	60 feet.
8-inch,	429 "

Approximate cost of masonry per linear foot, including underdrain, etc., $4.50.

Length completed,	1,014 feet.

Masonry begun, June 14, 1892; finished, Nov. 18, 1892.

Approximate cost of section per linear foot of trench and masonry, including labor, material and miscellaneous items, $14.50.

NOTE. — The information regarding Section 41 (day work) following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — There was but one opening, and from this hoisting was done by means of an incline. The extent of the work was one hundred and twenty feet, comprising fifty feet of ledge work between the ponds and the work from the upper pond to the end of the day work. The ordinary progress per week was fifteen feet, and was uninterrupted by shut-downs. A six-inch steam pump was located at Mountain Avenue and took care of the ground-water encountered. It is estimated that the greatest amount of ground-water pumped in any twenty-four hours was 720,000 gallons.

Foundation. — Between the ponds the foundation was upon ledge, and the balance of the way it was upon gravel. The concrete of the sewer rested on these natural foundations.

Miscellaneous. — The rock gained from the trench operations in Cochrane's yard was left there, and that gained in Mountain Avenue was taken away and used by the city of Malden. The sewer was encased in concrete masonry to prevent leakage.

Section 42, Melrose and Stoneham.

Location. — From a point in Wyoming Avenue, opposite Pleasant Street in Melrose, to a point in the same avenue in Stoneham, about 50 feet beyond the town line.

Length of section,	3,050 feet.

Diameter of sewer, 1 foot (vitrified bell pipe).

Contractor. — David L. Clements of Cleveland, Ohio.

During the year ending Sept. 30, 1893, Mr. Clements acted as his own superintendent, with Thomas Veber for his principal foreman.

State Assistants (Year ending Sept. 30, 1893).

Assistant Engineer: Wilbur F. Goodrich.
Inspectors: Henry M. Woodward, B. L. Sykes.
Transitmen: Assistants — Edward F. Adams, George F. Clark.

Trench and Pipe.

Length of trench completed,	3,050.00 feet.
Length of pipe laid,	3,050.00 "
Average depth of trench excavation to bottom of gravel refilling,	11.40 "
Greatest depth of trench excavation to bottom of gravel refilling,	16.00 "
Average width top of trench,	5.00 "
Average width bottom of trench,	2 99 "

Cubic yards excavation per linear foot of trench, 1.70.

Diameters of underdrain laid and length of each size: —

4-inch,	659 feet.
6-inch,	1,479 "

Pipe work begun, Aug. 15, 1892; finished, May 25, 1893.

Character of Earth Excavation. — Corner of Pleasant Street and Wyoming Avenue to Cleveland Street, very fine running sand with plenty of water; Cleveland Street to Lynde Avenue, peat; Lynde Avenue to a point four hundred feet beyond Whittier Street, peat and coarse sand; from thence to a point 250 feet beyond the Ravine Road, ledge; from thence to end of section, coarse sand.

Masonry (Man-holes).

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$16 00
Brick-work, Portland cement mortar, per cubic yard,	18 00
Concrete, American cement mortar, per cubic yard,	5 00

Number of man-holes built, 26.

Approximate cost per man-hole,	$49 78

Approximate cost of section per linear foot of trench and pipe (with man-holes), including labor, material and inspection, and miscellaneous items, $4.00.

Note. — The information regarding Section 42 following this note relates solely to the year ending Sept. 30, 1893. For a description of the work performed prior to this year, see the fourth annual report.

Excavation. — Steam drills were used in preparing for blasting the ledge encountered. The excavated material was thrown out by hand. Half-pound Atlas cartridges, 50 per cent. nitro-glycerine, were used for blasting. The work was carried on from two openings: Opening No. 1 extending from near Cottage Street to Lynde Avenue, a distance of about eight hundred and seventy-eight feet; and opening No. 2, from Lynde Avenue to a point about three hundred and fifty feet beyond the Ravine Road, a distance of about one thousand three hundred and eighty-six feet. A four-inch steam pump was located near Trenton and Florence Streets, and three hand pumps were also used. It is estimated that 144,000 gallons was the maximum amount of water pumped in twenty-four hours during the time of the greatest pumping. The ordinary progress per week at openings No. 1 and No. 2 was respectively sixty-five and forty feet. Two shut-downs took place: one on account of a strike of the contractor's men and the other from cold weather.

Foundation. — From the beginning of the section, opposite Pleasant Street, to Lynde Avenue, excavation was made to a depth of one foot below the bottom of the pipe and refilled with broken stone. Where ledge was encountered it was replaced by carefully tamped gravel for a depth of six inches below the bottom of the pipe. In peat the excavation was carried down to firm foundation and the pipe was founded on and surrounded by thoroughly compacted gravel. Fine running sand was encountered from the corner of Pleasant Street to Cleveland Street, and for this distance the pipe was laid in a cradle covered with broken stone such as was described in last year's report.

Difficulties. — From Cleveland Street to Lynde Avenue the Spot Pond Brook culvert ran on one side of the trench and a 16-inch cement water pipe on the other, the width between the two being six feet. Some difficulty was presented by the quicksand from Pleasant Street to Cleveland Street, and by the ledge from a point four hundred feet beyond Whittier Street to a point two hundred and fifty feet beyond the Ravine Road. At Cleveland Street the sewer pipe passed under Spot Pond Brook.

Accidents. — On March 28, Harry Bedell, while running a steam drill, struck and exploded an old cartridge. He was badly bruised and cut, but entirely recovered in due time.

Miscellaneous. — The surplus earth on this section was used by adjacent land owners.

SECTION 43, SOMERVILLE AND CAMBRIDGE.

Location. — From a point about 600 feet southerly from the Mystic Pumping Station, Somerville, extending in a south-westerly direction, near Alewife Brook, crossing Broadway, Somerville; North Avenue, Middlesex Central railroad, the Lexington & Arlington Branch railroad, the Massachusetts Central railroad and the Fitchburg railroad, to Concord Avenue, Cambridge; with branches at Broadway, Somerville; at the Middlesex Central railroad: and the Belmont Branch from the extension of Spruce Street, Cambridge, extending nearly parallel with the Massachusetts Central railroad to the Belmont town line.

Diameters of sewers, and length of each size: —

Main line: —		
2′ 11″ × 3′ 6″,		2,760 feet.
2′ 5″ × 3′ 1″,	2,330 feet.	
2′ 3″ × 2′ 11″,	1,730 "	
1′ 11″ × 2′ 9″,	1,170 "	
		5,230 "
1′ 6″ (vitrified pipe),		2,791 "
Belmont Branch: —		
1′ 3″ (vitrified pipe),		3,581 "

Contractors. — Metropolitan Construction Company of Boston, Mass.

Contractors' Superintendent. — George W. Judd.

Contractors' Principal Foremen. — P. Percello, Patrick Porter, Patrick Lynch, John Colleran.

State Assistants.

Assistant Engineer: Francis L. Sellew.

Inspectors: George A. Chase, John D. Collins, Paul Hill, Samuel P. McKenzie, Patrick McCarthy.

Transitmen: Principals — Hartley L. White, Edward S. Foster, George E. Howe.
" Assistants — George F. Chase, Nathan B. Wilber, W. Gordon Crispin.

Trench and Tunnel.

	Largest Size Masonry Sewer, Main Line.	Smaller Sizes Masonry Sewer, Main Line.	1′ 6″ Pipe, Main Line.	1′ 3″ Pipe, Belmont Branch.
Length of trench completed, feet,	1,483.00	3,298.00	2,795.00	3,581.00
Length of tunnel completed, feet,	-	100.00	-	-
Average depth of trench excavation to bottom of underdrain, feet,	20.00	10.50	7.0	7.0
Greatest depth of trench excavation to bottom of underdrain, feet,	30.00	16.00	10.0	11.0
Average width top of trench, feet,	7.00	4.80	4.5	4.5
Average width bottom of trench, feet,	5.50	4.80	4.5	4.5
Average depth from surface of ground to bottom of tunnel underdrain, feet,	-	16.00	-	-
Greatest depth from surface of ground to bottom of tunnel underdrain, feet,	-	17.00	-	-
Average width of tunnel excavation, feet,	-	4.50	-	-
Volume of trench excavation per linear foot, cubic yards,	4.4	1.9	1.2	1.2
Volume of tunnel excavation per linear foot, cubic yards,	-	.9	-	-
Approximate cost of trench or tunnel excavation per linear foot, including sheeting left in, excavation and refilling below masonry, back-filling, etc. to date (September 30),	$4 30	$2 70	$2 10*	$2 05*

* Including pipe.

Character of Earth Excavation. — Main line beginning at lower end of section and extending southerly a distance of about one thousand four hundred and fifty feet, strata consisting of one foot of loam on three to five feet of sand, hard-pan to bottom of trench; from a point about five hundred feet north-easterly from North Avenue to a point about five hundred feet south-westerly from the same avenue, a two-foot stratum of clay on a four-foot one of sand, with blue clay beneath, — from thence in the same direction to the Middlesex Central railroad, a two-foot stratum of peat with fine sand below; from Spruce Street to Concord Avenue, a stratum of three feet of peat, with fine sand below: Belmont branch for fifteen hundred feet from Spruce Street, three-foot stratum of peat with fine sand below; thence to Fitchburg railroad, all peat; beyond, gravel and fine sand.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard, 4 inches thick,	$13 95
More than 4 inches thick,	13 65
Brick-work, Portland cement mortar, per cubic yard, 4 inches thick,	15 75
More than 4 inches thick,	15 45
Concrete, American cement mortar, per cubic yard,	6 50
Concrete, Portland cement mortar, per cubic yard,	8 25
Diameters of underdrain laid and length of each size: —	
6-inch,	170 feet.
8-inch,	3,521 "
10-inch,	827 "
Approximate cost of masonry per linear foot of excavation, including underdrain, etc. to date (September 30): —	
Largest size (trench)	$4 30
Smaller sizes (trench and tunnel),	4 00
Length completed, trench, 4,040 feet; tunnel, 100 feet,	4,140 feet.

Masonry was begun May 1, 1893, and is now (September 30) in progress.

Pipe.

Contract price (including excavation, pipe and laying, etc.): —	
Main line, 1′ 6″ vitrified pipe, per linear foot,	$1 95
Belmont branch, 1′ 3″ vitrified pipe, per linear foot,	1 39
Diameters of underdrain laid and length of each size: —	
6-inch,	1,356 feet.
8-inch,	3,624 "

Length of sewer pipe laid: —

Main line, 1′ 6″, 2,791 feet; Belmont branch, 1′ 3″, 3,581 feet, — 6,372 feet.

Pipe laying begun, Nov. 24, 1892; finished, Aug. 7, 1893.

Approximate cost of section per linear foot of excavation, masonry and pipe, including labor, material and inspection and miscellaneous items to date (September 30):	
Main line: —	
Largest size masonry sewer,	$9 40
Smaller sizes masonry sewer,	7 40
1′ 6″ pipe sewer,	4 50
Belmont branch, 1′ 3″ pipe sewer,	4 00

Excavation (*Main line*). — Operations were pursued from five open cuts and one tunnel, as follows: — Open cut, foot of Spruce Street, begun Nov. 24, 1892, south-easterly for about two thousand

eight hundred feet, by hand method; open cut, foot of Spruce Street, beginning May 15, 1893, north-westerly for about six hundred feet, by hand method; open cut at lower end of section, beginning May 1, 1893, about one thousand four hundred and fifty feet in a southerly direction, by trench machine; open cut at North Avenue, beginning June 24, 1893, south-westerly for about two thousand two hundred and forty-six feet, by hand method; open cut at North Avenue, beginning Aug. 22, 1893, north-easterly for about five hundred feet, by hand method; tunnel under North Avenue, beginning Aug. 23, 1893, a distance of about one hundred feet, an incline being used to remove the material excavated through the shaft. The ordinary progress per week at these openings, in the order named, was about as follows: three hundred, one hundred and fifty, ninety-six, three hundred, two hundred, twenty-five feet. The distribution of the pumping plant has been as follows: A four-inch pulsometer at the lower end of the section; an eight-inch centrifugal pump at a point about one hundred and fifty feet southerly from North Avenue; a six-inch centrifugal pump near the Middlesex Central railroad; a four-inch pulsometer at the foot of Spruce Street. It is estimated that 125,000 gallons of water were pumped per twenty-four hours during the time of maximum pumping.

Excavation (*Belmont branch*). — Work was started Nov. 24, 1892, at the foot of Spruce Street, Cambridge, from which trench operations have extended for a distance of about three thousand five hundred and eighty-one feet. The ordinary progress per week has been about two hundred feet. The pumping of ground-water has been done by a six-inch centrifugal pump at a point about fourteen hundred feet from Spruce Street, and an eight-inch centrifugal pump at a point about eighteen hundred feet from the same street. During the time of maximum pumping it is estimated that 250,000 gallons of water were pumped in twenty-four hours. Work was shut down on all parts of the section from Dec. 30, 1892, to April 17, 1893, on account of cold weather.

Foundation (*Main line*). — In the opening at the lower end of the section the bottom of the trench was of hard-pan. From a point about one hundred feet north-easterly from North Avenue to a point about five hundred feet southerly from that avenue the bottom of the trench was excavated to fit the invert of the sewer. From a point about five hundred feet southerly from North Avenue to the Middlesex Central railroad, and from Spruce Street to Con-

age depth of about one and one-half feet below the bottom of the masonry. This space was filled with screened gravel at the first of these places, and with crushed stone at the second.

Foundation (*Belmont branch*). — The bottom of the trench for nearly the entire length has been excavated to an average depth of one and one-half feet below the bottom of the masonry. The space thus left has been filled with crushed stone. For a distance of about one thousand feet, from the upper end of the section to a point about fifteen hundred feet south-westerly from Spruce Street, piles averaging about thirty feet in length have been driven in bents of two and capped with four-inch by eight-inch spruce.

Miscellaneous. — The main sewer has crossed once each under the Middlesex Central and the Massachusetts Central railroads, and twice under the Fitchburg railroad, and has crossed under the Alewife Brook at the foot of Spruce Street. At all of these points the sewer arch was increased by six inches of Portland concrete. The railroad tracks were supported by timbers during the time of crossing. The surplus earth has so far all been left within the taking lines.

SECTION 43½ (CONTRACT WORK), MEDFORD AND SOMERVILLE.

Location. — From the junction of Canal and Prescott Streets, Medford, through Canal Street to within 25 feet of Mystic River (leaving 149 feet at the river to be done directly by the State); from 50 feet southerly of Mystic River, through Boston Avenue and private land to a point about 600 feet southerly from the Mystic Pumping Station — omitting from the contract work a space of about 118 feet for the pumping station which it is proposed to have situated about 300 feet southerly from the Mystic Pumping Station.

Diameters of sewers and length of each size: —

3 feet by 3 feet 7 inches,	2,056 feet.
2 feet 11 inches by 3 feet 6 inches,	256 "

Contractors. — Metropolitan Construction Company of Boston, Mass.
Contractors' Superintendent. — George W. Judd.
Contractors' Principal Foremen. — James Long, Patrick Porter.

State Assistants.

Assistant Engineer: Francis L. Sellew.
Inspector: George A. Chase
Transitmen: Principal — George E. Howe.
" Assistants — Nathan B. Wilber, W. Gordon Crispin.

Trench.

Length completed,	2,327.00 feet.
Average depth of excavation to bottom of underdrain,	13.10 "
Greatest depth of excavation to bottom of underdrain,	22.20 "
Average width top of trench,	6.00 "
Average width bottom of trench,	5.00 "

Cubic yards, excavation per linear foot, 2.67.

Approximate cost of trench per linear foot, including sheeting left in, excavating and refilling below masonry, backfilling, etc., $4.00.

Character of Earth Excavation. — In Canal Street, sand and gravel to within four or five feet of water line, with sandy clay below; in Boston Avenue, gravel filling to water line; private land to Mystic Pumping Station, three or four feet of ashes, with hard gravelly clay below; upper two hundred feet of section, one and one-half feet of loam, then indurated clay to within four feet of water line, with soft blue clay below.

Masonry.

Contract price: —	
Brick-work, American cement mortar, per cubic yard,	$12 50
Brick-work, Portland cement mortar, per cubic yard,	14 25
Concrete, American cement mortar, per cubic yard,	5 75
Concrete, Portland cement mortar, per cubic yard,	7 50
Diameters of underdrain laid and length of each size: —	
2-inch,	94 feet.
6-inch,	1,290 "
10-inch,	672 "
Approximate cost of masonry per linear foot of trench, including underdrain, etc.,	$5 60
Length of masonry completed,	2,312 feet.

Masonry begun, June 2, 1893; finished, Sept. 20, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items, $11.50.

Excavation. — The excavating has been done by open cut and as shown below: —

	Opening No. 1.	Opening No. 2.	Opening No. 3.
Date of starting,	May 24, 1893,	May 31, 1893,	July 19, 1893.
Point of beginning,	600 feet south of Mystic Pumping Station.	200 feet south of Mystic Pumping Station.	West bank of Mystic River.
Point of ending,	340 feet south of Mystic Pumping Station.	East bank of Mystic River near Boston Avenue.	Junction with Section 21 at corner of Prescott and Canal Streets.
Extent,	260 feet,	1,292 feet,	795 feet.
Ordinary progress per week.	96 feet,	120 feet,	150 feet.
Appliances used,	Trench machine,	Thrown out by hand,	Derricks for first two hundred feet, trench machine for five hundred feet.

eter at a point about six hundred feet south of Mystic Pumping Station and a six-inch centrifugal pump in Canal Street, the estimated maximum amount pumped in any twenty-four hours being 216,000 gallons. The excavation work was carried on continuously.

Foundation. — The bottom of the trench was shaped to fit the invert of the sewer for two hundred and five feet in Canal Street, six hundred and twenty-three feet in Boston Avenue and private land, and for two hundred feet at the upper opening. For a distance of five hundred and ten feet in Canal Street the underlying fine, sandy clay was removed to a depth of from six to eighteen inches below the bottom of the masonry and replaced with gravel; and for a distance of seventy feet on Boston Avenue it was removed to a depth of from one to four inches and replaced with concrete. Pile driving was resorted to for one hundred feet in Boston Avenue and in the marsh toward the river. The piles were from ten to twenty feet long, driven in bents of two, and the tops capped with eight-inch by eight-inch spruce timber.

Miscellaneous. — The sewer was built without difficulty under the Southern Division of the Boston & Maine railroad in Canal Street. The arch was here reinforced with six inches of Portland concrete. Fourteen-inch by sixteen-inch yellow pine timber was placed under the tracks, one timber under each rail. The arch for four hundred feet near Mystic Pumping Station, and for thirty feet on each side of Mystic River was also reinforced with concrete. For thirty feet near the Mystic River in Medford the crown of the arch comes within one to three feet of the natural surface. For a distance of two hundred and fifty feet near the Mystic Pumping Station in Somerville the sewer arch is within two to three feet of the natural surface. An embankment increasing in height from a few inches to seven and one-half feet above the natural surface has been built over the sewer on the marsh near Boston Avenue, and one increasing in the same manner to five feet has been built south of the Mystic Pumping Station, Somerville. The remaining portion of the surplus earth on this section has been left on private land, with the owners' consent.

SECTION 44, WINCHESTER.

Location. — From a point on the easterly side of the Boston & Lowell railroad about 150 feet southerly from Mystic Station, running northerly crossing Bacon Street and through private and railroad land, crossing the Boston & Lowell railroad about 300 feet southerly from Winchester Station; thence on the westerly side of the railroad through Common and Main Streets, crossing Wedge Pond Culvert to Lake Street; thence through private lands, and crossing Blind Bridge Street and the Woburn Branch railroad; thence along the north-easterly side of the railroad to a point about 500 feet south of Beggs & Cobb's tannery.

Diameters of sewers and length of each size: —

2 feet 7 inches by 2 feet 11 inches,	3,078 feet.
2 feet 3 inches by 2 feet 6 inches,	1,622 "
2 feet by 2 feet 5 inches,	908 "

Contractors. — Jones & Meehan of Jamaica Plain, Mass.
Contractors' Superintendent. — James D. Fallon.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspectors: Lucius M. S. Horton, Warren A. Rogers.
Transitmen: Principal — Paul W. Rowell.
" Assistants — George R. Winslow, Joseph M. Mahoney.

Trench and Tunnel.

Length completed of trench excavation,	3,023.00 feet.
Length completed of tunnel excavation,	198.00 "
Average depth of trench excavation to bottom of underdrain,	13.30 "
Greatest depth of trench excavation to bottom of underdrain,	15.30 "
Average width top of trench,	4.50 "
Average width bottom of trench,	4.50 "
Average depth from surface of ground to bottom of tunnel underdrain: —	
Under Bacon Street,	28.00 "
In freight yard and under railroad,	13.00 "
Greatest depth from surface of ground to bottom of tunnel underdrain,	28.00 "
Average width of tunnel excavation,	5.00 "

Cubic yards trench excavation per linear foot, 2.00.
Cubic yards tunnel excavation per linear foot, 1.00.
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, back filling, etc., to date (September 30), $4.00.
Approximate cost of tunnel excavation per linear foot, including excavation and refilling below masonry, back filling, etc., to date (September 30), $3.50.

Character of Earth Excavation. — For about three hundred feet from the southerly end of the section, sand and then coarse sand and gravel. For about one hundred and twenty feet in the freight yard there was some ledge. Near the Winchester Station and in Common Street fine sand was found in the lower part of the trench. The balance was sand and gravel.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$14 00
Brick-work, Portland cement mortar, per cubic yard,	17 00
Concrete, American cement mortar, per cubic yard,	7 00
Concrete, Portland cement mortar, per cubic yard,	9 00

Diameter of underdrain laid, and length: —

8-inch,	3,221 feet.

Approximate cost of masonry per linear foot of excavation, including underdrain, etc., to date (September 30): —

Trench,	$4 70
Tunnel,	8 10

Lengths of masonry completed: —

Trench,	2,949 feet.
Tunnel,	198 "

Masonry was begun in trench: concrete, June 21, 1893; brick masonry, June 22, 1893 — is now (September 30), in progress.

Masonry begun in tunnel, July 27, 1893; finished, Sept. 14, 1893.

Approximate cost of section per linear foot of excavation and masonry, including labor, material and inspection, and miscellaneous items to date (September 30): —

Trench,	$9 00
Tunnel,	11 70

Excavation. — On the easterly side of the railroad the earth was thrown out of the trench by hand. On the westerly side of the railroad, beginning at a point about two hundred feet southerly from the Winchester Station, a trench machine was used. Further information regarding the excavation by openings — all open cut — is shown in the tabular statement below: —

	Opening No. 1.	Opening No. 2.	Opening No. 3.	Opening No. 4.
Date of starting,	June 13, 1893,	June 26, 1893,	July 18, 1893,	Aug. 11, 1893.
Point of beginning,	Back of Mystic Station.	Southerly end of freight yard.	South of Bacon Street.	South of Winchester Station.
Point of ending,	Southerly end of freight yard.	300 feet south of Winchester Station.	Back of Mystic Station.	Near the intersection of Common and Church Streets.
Ordinary progress per week.	About 50 feet,	About 50 feet,	About 50 feet,	About 150 feet.

Opening No. 2 includes two bores under branch tracks and one under main line track, of the aggregate length of one hundred and forty feet. Opening No. 3 includes about fifty-eight feet of tunnel under Bacon Street. Two centrifugal pumps, one four-inch and one six-inch, have been used along the line at pump wells about five hundred feet apart, with the exception that the distance between the first two wells was about one thousand three hundred feet. At the time of the maximum pumping it is estimated that 1,200,000 gallons of ground-water was removed in twenty-four hours. The work of excavation was carried on continuously.

Foundation. — On the easterly side of the railroad, near the freight house, the underlying earth in the trench was removed to a depth of from six inches to one foot below the bottom of the masonry and replaced with gravel. The same was also done beside the Winchester Station and in a portion of Common Street.

Difficulties. — Between Mystic Avenue and the freight yard about one hundred feet of retaining wall by the side of the river had to be removed and the sewer built in the foot of the wall between the river and the railroad. From the beginning of the section to the freight yard the line of the sewer is parallel with, about twelve feet easterly from, and about five feet below the line of the old Mystic Valley sewer. Near the northerly end of the freight yard the Metropolitan sewer passes under this old sewer. The tunnels under the railroad tracks and at Bacon Street were filled with concrete outside of the brick masonry of the sewer. Through the yard the brick masonry was reinforced with concrete to a point about six inches over the arch. At the Mystic Valley sewer crossing, the arch of the Metropolitan sewer was covered with concrete and a concrete pier built up to the springing line of the Mystic Valley sewer.

Miscellaneous. — The arch of all the sewer, except where otherwise specified above, was covered with Portland cement plaster, to lessen the percolation of water. South of the retaining wall north of Mystic Avenue about twenty-six feet of the bank of the river was protected with hand-laid rip-rap. Most of the surplus earth gained in the sewer operations has been used by people in Winchester, for filling.

Section 44½, West Medford and Winchester.

Location. — From the southerly end of section 22, in Medford, near the outlet of the Mystic Valley sewer at the lower Mystic Lake, along the bed of the old Middlesex Canal and through private and railroad lands on the westerly side of the Boston & Lowell railroad, crossing the Abbajona River and across said railroad to a point on its easterly side about one hundred and fifty feet southerly from Mystic Station in Winchester. The proposed pipe crossing at Abbajona River is not embraced in the contract work.

Length of section,	5,684 feet.
Diameters of sewers and length of each size: —	
2 feet 11 inches by 3 feet 3 inches,	3,298 "
2 feet 9 inches by 3 feet 1 inch,	2,306 "
Proposed pipe crossing at Abbajona River (to be let in another contract),	80 "

Contractors. — Weaving, Booth & Co., of Dorchester, Mass.

Contractors' Superintendent. — A. E. Weaving, a member of the above-named firm.

Assistant Engineer: Edmund S. Davis.
Inspector: M. F. Garra.
Transitmen: Principal — Arthur Henri Pratt.
" Assistant — Joseph M. Mahoney.

Trench.

Length completed,	1,583.00 feet.
Average depth of excavation to bottom of masonry,	8.00 "
Greatest depth of excavation to bottom of masonry,	16.00 "
Average width top of trench,	6.00 "
Average width bottom of trench,	4.50 "

Cubic yards excavation per linear foot, 1.41.

Approximate cost of trench per linear foot, including excavation and refilling below masonry, backfilling, etc., to date (September 30) $1.70.

Character of Earth Excavation. — Sand and gravel, a few boulders; some peat just north of the Abbajona River.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$11 75
Brick-work, Portland cement mortar, per cubic yard,	13 20
Concrete, American cement mortar, per cubic yard,	3 40
Concrete, Portland cement mortar, per cubic yard,	4 65

Diameters of underdrain laid and length of each size: —

6-inch,	586 feet.
8-inch,	608 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30), $3.30.

Length of masonry completed, ... 1,395 feet.

Masonry was begun: concrete, Sept. 2, 1893; brick masonry, Sept. 6, 1893 — is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items to date (September 30), $5.30.

Excavation. — The earth has thus far been thrown out of the trench by hand, and the work has proceeded from two open cuts. The first of these was begun Aug. 28, 1893, at a point about one thousand nine hundred feet south of the Abbajona River, operations from which have extended a distance of about one thousand three hundred and fifty-six feet to a point about one hundred feet north of Bacon's Private Way. The second opening was begun Sept. 19, 1893, just north of the above-named river, and the work from it has now covered a distance of about two hundred and twenty-seven feet to the Boston & Lowell railroad crossing about three hundred feet southerly from Mystic Station. A four-inch centrifugal pump was used near the beginning of the first opening, the maximum amount of ground-water handled by it in any twenty-four hours being estimated to be 50,000 gallons. The ordinary progress per week at the two openings was as follows: First opening, about three hundred and forty feet; second opening,

about one hundred and fifty feet. The operations have been free from shut-downs.

Foundation. — The bottom of about one thousand feet of the trench extending southerly from Bacon's Private Way has been shaped to fit the invert of the sewer. The unstable foundation met for the first sixty-three feet of opening No. 1 was removed to a depth of about eight inches below the bottom of the masonry to the sand and gravel beneath, and the intervening space filled with gravel. Excavation below the bottom of the masonry was also made for the first seventy-nine feet of the second opening. The greatest depth here below grade was at the beginning, where it was about 3.37 feet, — the average depth being 2.04 feet. The refilling was done with American concrete.

Difficulties. — The sewer crosses under the Boston & Lowell railroad at a point about two hundred and fifty feet south of the Mystic Station, and the arch is here re-enforced with Portland concrete to a point six inches above the crown.

Miscellaneous. — About eighty feet of the sewer arch north of the Abbajona River is above the surface. The greatest height above is about 3.8 feet. This exposed arch will be protected by an embankment made from the surplus earth gained in excavation.

Section 45, Winchester.

Location. — From a point on the northerly side of the Woburn Branch railroad about five hundred feet south of Beggs & Cobb's tannery on the northwesterly side of Wedge Pond, through private and railroad lands, crossing Swanton and Cross Streets and the Boston & Lowell railroad to Washington Street, near the entrance to Calvary Cemetery.

Diameters of sewers and length of each size: —

2 feet by 2 feet 5 inches,	4,540 feet.
1 foot 10 inches by 2 feet 3 inches,	1,968 "

Contractors. — Everson & Liddle of Providence, R. I.
Contractors' Superintendent. — J. J. Everson, a member of the above-named firm.
Contractors' Principal Foreman. — John J. Galligan.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspectors: E. A. Clark.
Transitman: Principal — Guy C. Emerson.
" Assistant — J. T. P. Jones.

Trench.

Length completed,	6,508.00 feet.
Average depth of excavation to bottom of underdrain,	9.60 "
Greatest depth of excavation to bottom of underdrain,	19.40 "
Average width top of trench,	3.85 "
Average width bottom of trench,	3.85 "

Cubic yards excavation per linear foot, 1.28.

and refilling below masonry, backfilling, etc., to date (September 30), $1.60.

Character of Earth Excavation. — First seven hundred feet, tan bark to near the sewer bottom; for about eight hundred feet north from Swanton Street, loamy peat on surface, sand and gravel below; along the line of Cross Street, coarse sand and gravel with the exception that there was peat for about 280 feet west of the Boston & Lowell railroad; Cross Street to the Watch Hand Factory, deep loam on surface, sand and gravel below; thence to Washington Street, loam on surface, sand and gravel below — which at a depth of about three feet from the surface occasionally changed to fine sand mixed with clay.

Masonry.

Contract price: —

Brick-work, American cement mortar, per cubic yard,	$12 00
Brick-work, Portland cement mortar, per cubic yard,	14 00
Concrete, American cement mortar, per cubic yard,	5 50
Concrete, Portland cement mortar, per cubic yard,	6 50

Diameters of underdrain laid, and length of each size: —

6-inch,	970 feet.
8-inch,	5,538 "

Approximate cost of masonry per linear foot of trench, including underdrain, etc., to date (September 30), $2.80.

Length of masonry completed, ... 6,164 feet.

Masonry was begun: concrete, May 12, 1893; brick masonry, May 23, 1893, and is now (September 30) in progress.

Approximate cost of section per linear foot of excavation and masonry, including labor, material, inspection, and miscellaneous items, to date (September 30) $6.00.

Excavation. — The earth has been taken from the trench without the use of hoisting apparatus. The single opening on this section was begun near the Woburn Branch railroad, at a point about five hundred feet south of Beggs & Cobb's tannery, on May 2, 1893. Operations have now (September 30) nearly reached the end of the section at Washington Street. The plant used in pumping the ground-water has consisted of a four-inch and six-inch centrifugal pump, used at pump wells about one thousand feet apart as needed. The greatest amount of ground-water pumped in any twenty-four hours was estimated to be 800,000 gallons. The progress of excavation has been continuous, and has ordinarily been about three hundred feet per week.

Foundation. — The underlying earth has been removed to a depth of eight inches below the bottom of the masonry for about five hundred feet near Swanton Street, and between the Watch Hand Factory and Washington Street. It has been replaced with screened gravel near Swanton Street, and with unscreened gravel at the other locality. Peat was encountered for about two hundred and eighty feet west of the Boston & Lowell railroad, and a pile foundation was here put in. The piles were from eight to thirty

feet long (averaging about seventeen feet), were driven in bents capped with eight-inch by eight-inch timber and covered with a four-inch platform.

Difficulties. — The sewer has been built under the Boston & Lowell railroad in Cross Street at the overhead railroad bridge. It crosses four times the old bed of Willow Brook north of Cross Street and the canal, or tail-race, from the Watch Hand Factory; also a small canal or culvert in Washington Street supplying water for power to run the same factory. At the creek crossings, and under the Boston & Lowell railroad in Cross Street, the sewer has been reinforced with Portland concrete to a height of six inches above the arch. Instead of the brick sewer, twenty-four-inch Akron pipe was laid in concrete at two ditch crossings between Swanton Street and the Boston & Lowell railroad, at one of the creek crossings north of Cross Street, and under the tail-race of the Watch Hand Factory.

Miscellaneous. — The sewer line as at first projected has been changed between a point in Cross Street about seventy-five feet easterly from the railroad bridge at Winchester Highlands and a point about two hundred feet southerly from the Watch Hand Factory. The distance between these points is about one thousand three hundred and forty feet, and the saving by the change has been about eighty-four feet. The heirs of the estate of Samuel Richardson decided to change the course of Willow Brook through their premises, which made this change in the line of the sewer advantageous. In order to lessen the percolation of water the entire arch, except where it is of eight-inch brick-work in Cross Street, has been covered with an extra coat of Portland cement concrete, three-fourths of an inch thick. The crown of the sewer arch for about two hundred and eighty feet in the meadow west of the Boston & Lowell railroad is within six inches of the surface of the ground, and the crown is within one and one-half feet in the meadow north of Cross Street. An embankment of the surplus earth is being built over the sewer at these places with its top about three feet above the arch. The section will probably be finished before the middle of October.

SECTION 46, WINCHESTER, WOBURN AND STONEHAM.

Location. — From Washington Street near the entrance to Calvary cemetery, in Winchester, through private lands on the westerly side of Willow Brook, crossing Willow Brook and thence through private lands on the easterly side of Clear Water Brook, crossing Hill Street, Stoneham Branch railroad and Maple Street in Woburn to Montvale Avenue in Stoneham near the Woburn and Stoneham town line.

Diameters of sewers and length of each size: —

1 foot 10 inches by 2 feet 3 inches, ... 2,375 feet.
1 foot 6 inches by 2 feet, ... 1,081 "
1 foot 3 inches (Akron pipe), ... 2,300 "

Contractor. — Charles Linehan of Cambridge, Mass., — Mr. Linehan acting as his own superintendent.

Contractor's Principal Foreman. — Giuseppe Chino.

State Assistants.

Assistant Engineer: Edmund S. Davis.
Inspectors: Edward A. Clark, Hadson B. Damon, Paul Hill.
Transitman: Principal — Guy C. Emerson.
" Assistant — J. T. P. Jones.

Trench.

	Brick Sewers.	Pipe Sewer.
Length completed, feet,	3,456.00	820.00
Average depth of excavation to bottom of underdrain, feet,	10.50	8.20
Greatest depth of excavation to bottom of underdrain, feet,	18.00	18.00
Average width top of trench, feet,	3.68	3.50
Average width bottom of trench, feet,	3.68	3.00
Volume of excavation per linear foot, cubic yards,	1.32	.93
Approximate cost of trench per linear foot, including sheeting left in, excavation and refilling below masonry, backfilling, etc., to date (September 30),	$1 40	-

Character of Earth Excavation. — Mostly sand and gravel. Between Willow Brook and Oakland some earth resembling hard pan was found.

Masonry and Pipe.

Contract price: Masonry —
Brick-work, American cement mortar, per cubic yard, ... $13 00
Brick-work, Portland cement mortar, per cubic yard, ... 16 00
Concrete, American cement mortar, per cubic yard, ... 5 00
Concrete, Portland cement mortar, per cubic yard, ... 6 00

Contract price: pipe sewer —
1 foot 3 inch pipe sewer (including trench), ... 1 36

Diameters of underdrain laid and length of each size: —
6-inch, ... 2,105 feet.
8-inch, ... 2,084 "

Approximate cost of masonry or pipe per linear foot of trench, including underdrain, etc., to date (September 30): —
Brick sewers, ... $3 10
Pipe sewer (including trench and brick man-holes), ... 1 50

Length completed: —

Brick sewers,	3,456 feet.
Pipe sewer,	707 "

Masonry begun, April 26, 1893; finished, Sept. 19, 1893, — except putting concrete around pipe under railroad and building some brick man-holes on pipe sewer.

Pipe laying was begun, Sept. 19, 1893, and is now (September 30) in progress.

Approximate cost of brick sewers per linear foot, including excavation and masonry, labor, material, inspection and miscellaneous items, to date (September 30), $5.00.

Approximate cost of the 1 foot 3 inch pipe sewer per linear foot of excavation and pipe, including masonry at man-holes, labor, material and inspection and miscellaneous items to date (September 30), $1.70.

Excavation. — The earth has been thrown from the trench by hand. The single opening on this section was started April 5, 1893, on Washington Street, Winchester, near Calvary cemetery. Work has now (September 30) reached the Stoneham Branch railroad in Woburn, about seven hundred and fifty feet easterly from Oakland Station. The crossing under the tracks has (September 30) just been commenced, by tunnel. The excavation work has been pursued continuously, and has ordinarily progressed about one hundred and sixty feet per week. The pumping of ground-water has been done by two four-inch centrifugal pumps used alternately at pump wells about nine hundred feet apart, the first of the series being located near Washington Street. The greatest amount of ground-water pumped in any twenty-four hours is estimated to have been about 500,000 gallons.

Foundation. — The bottom of trench was generally of very good sand and gravel. At two short places on the westerly side of Willow Brook some fine wet sand was found in the bottom and was removed to a depth of about eight inches below the grade of the bottom of the concrete and replaced with screened gravel. The concrete invert was in other places built upon the natural foundation.

Miscellaneous. — A twenty-inch diameter Akron pipe laid in concrete was employed at the Willow Brook crossing instead of the brick sewer. At the glue factory in Oakland a ten-inch diameter Akron pipe was laid underneath the sewer to supply water to a pump well in the factory yard. This pipe replaced a wooden box which crossed the line of the sewer at an elevation which would have interfered with the sewer. The well was deepened about two feet. Between Washington and Hill Streets the arch of the sewer has been covered with an extra coat of Portland cement plaster, to lessen the percolation of water. For the greater portion of the work the property owners have requested that the surplus earth be left on the ground.

accommodate the needs of the work. Many of those mentioned in the foregoing detailed account of sections have thus spent but a comparatively short time on the sections where they are mentioned.

Sections 1 (Deer Island Outlet), 3½ (Shirley Gut siphon), 10 (siphon under Chelsea River), 25 (siphon under Mystic River, Charlestown), and other pieces of work involving much more than the ordinary risk and on which it might be necessary to change the plan during construction, have been or are now being done by foremen and laborers directly under the supervision of the engineering department instead of by contract. On work in general the contract system is preferable.

Table of Progress.

The following table recapitulates to some extent the detailed information given in the foregoing report and in those of preceding years. The Charles River valley sections are designated by letters, and those of the North Metropolitan district by numbers: —

TABLE OF SEWER WORK COMPLETED AND IN PROGRESS SEPT. 30, 1893.

Section.	Locality.	Name of Contractor.	Total Length of Section. Feet.	Size of Sewer.	Average Depth of Trench, Bottom of Underdrain or Deeper Excavation. Feet.	Length of Sewer Completed September 30. Feet.	Date of Completion named in Contract.
O,	Boston,	Built by city of Boston,	1,897	6' 6",	23	1,897	May, 1890
A,	Boston,	H. C. Eyre,	3,701	5' 6",	20.3	3,701	Aug. 31, 1891
B,	Boston and Brookline,	H. C. Eyre,	2,965	5' 6",	18.5	2,965	Feb. 28, 1891
C,	Brighton,	National Construction Co.,	5,787	4' 10",	16.4	5,787	Aug. 31, 1891
D,	Brighton,	National Construction Co.,	5,300	4' 10",	17.2	5,300	July 31, 1891
E,	Brighton,	Jones & Meehan,	8,027	4' 6"×5' 1",	14.7	8,027	Nov. 30, 1891
F,	Newton and Watertown,	Jones & Meehan,	7,673	4' 2"×4' 9", 3' 11"×4' 5",	10.4	7,673	Nov. 30, 1891
G,	Newton,	Jones & Meehan,	2,800	3' 11"×4' 5", 3' 6"×4',	19.1	2,800	Nov. 30, 1891
H,	Newton,	Metropolitan Construction Co.,	4,517	3' 6"×4',	13.7	4,500	Nov. 30, 1891
1,	Deer Island,	Day work,	1,950	6' 3",	14.0	500	-
2,	Deer Island,	National Construction Co.,	2,136	Outfall sewer, 6'×6' to 6'×10',	17	2,120	Feb. 29, 1892
				Main sewer, 9',	28		
3,	Deer Island,	R. A. Malone & Co.,	2,641	9',	26	2,641	Apr. 30, 1891
3½,	Deer Island and Winthrop,	Day work,	430	Main sewers, 9', 6' 2",	-	-	-
				Sand catcher, 16'×16',	-	-	-
				Siphon, 6' 2",	14	240	-
4,	Winthrop,	Metropolitan Construction Co.,	5,710	9',	22	5,710	June 30, 1891
5,	Winthrop,	Metropolitan Construction Co.,	4,600	9',	16	4,600	July 31, 1891
6,	Winthrop,	Metropolitan Construction Co.,	4,113	9',	18	4,113	May 31, 1891
7,	Winthrop and East Boston,	Trumbull & Ryan,	848	Main sewer, 8' 6"×9' 2",	6.5	576	June 1, 1893
				Sand catcher, 16'×16' 5," and siphon approaches.	11.4		
				Siphon (3 parallel lines), 5',	13.6		
8,	Breed's Island,	Charles Linehan,	4,126	9',	16.4	4,126	Aug. 31, 1891
9,	East Boston,	Charles Linehan,	3,383	9',	15.8	3,383	May 31, 1891
10,	East Boston and Chelsea,	Day work,	709	Siphon, 5' 8",	52.9	626	-
				Sand catcher, 15' 5"×16' 1",	21.0		
12,	Chelsea,	Day work,	* 116	8' 4"×9',	25.00	116	-
12,	Chelsea,	Orin P. Roberts,	3,035	8' 4"×9',	27.00	3,014	Apr. 30, 1893

* Rebuilt.

TABLE OF SEWER WORK COMPLETED, ETC. — CONCLUDED.

Section.	Locality.	Name of Contractor.	Total Length of Section. Feet.	Size of Sewer.	Average Depth of Trench, Bottom of Underdrain or Deeper Excavation. Feet.	Length of Sewer Completed September 30. Feet.	Date of Completion named in Contract.
14,	Chelsea,	Metropolitan Construction Co.,	3,445	8' 10", 8' 4"×9', 8' 2"×8' 10,"	28.60* 37.0†	3,445	Dec. 30, 1893
15,	Chelsea,	Christy McBride,	1,754	8' 2"×8' 10",	23.2	1,754	May 31, 1892
16,	Everett,	R. A. Malone & Son,	4,431	8' 2"×8' 10", 5' 10"×6' 4",	20.1 20.7	4,431	Nov. 30, 1892
17,	Everett,	Christy McBride,	3,542	5' 10"×6' 4", 4' 8"×5' 1".	21.4	3,542	Sept. 30, 1892
17½,	Everett,	Metropolitan Construction Co.,	1,627	4' 8"×5' 1",	17.0	1,627	Sept. 30, 1892
20,	Medford,	John Sheehan,	9,170	Main line, 4' 8"×5' 1", 4' 5"×4' 8", Edgeworth branch, 2',	18.5 13.3	9,170	Apr. 30, 1893
21,	Medford,	National Construction Co.,	8,030	4' 5"×4' 8", 4' 3"×4' 6",	14.0	8,030	Feb. 28, 1893
21,	Medford (Gravelly Brook culvert),	Sub-contractors: Wm. H. Lenox & Co., A. W. Bryne,	54	4' 5"×4' 8",	12.8	54	-
21,	Medford (Winthrop Street culvert),	Day work,	181	4' 3"×4' 6",	6.5	181	-
22,	West Medford,	Andrew W. Bryne,	6,056	3' 4"×3' 6",	23.0* 28.0†	5,078	June 30, 1893
23,	Everett,	R. A. Malone & Sons,	2,268	6'×6' 8",	25.3	2,268	June 30, 1892
24,	Everett and Charlestown,	Metropolitan Construction Co.,	2,332	6'×6' 8",	25.0	2,332	Sept. 30, 1892
25,	Charlestown,	Day work,	1,336	Main sewer, 6'×6' 8", Siphon, 5',	—* 45.3†	425	-
26,	Charlestown and Somerville,	Harry P. Nawn,	3,750	6' 5"×7' 2", 5' 9"×6' 6",	34.3† 23.5* 28.8†	3,702	Nov. 30, 1893
26,‡ 27,‡	Somerville,	Day work,	950	5' 9"×6' 6",	35.0†	950	-
27,	Somerville and Cambridge,	McGovern & Kitch,	4,326	5' 9"×6' 6", 5' 2"×5' 9",	24.40* 22.9* 24.9†	3,960	Aug. 31, 1893
28,	Cambridge,	John L. Reardon & Co.,	6,500	4'×4' 6",	17.9* 21.6†	5,518	Apr. 30, 1894
29,	Cambridge,	Lindsay & Cudmore,	5,154	4'×4' 6", 3' 8"×4' 2", 3' 6"×4',	16.2 12.9 14.5	3,112	Nov. 30, 1893

30,	Cambridge,	Jones & Meehan,	7,025	3' 5"×3' 8",	13.8	4,972	Apr. 30, 1894
				2' 10"×3', 2' 6"×2' 10",	15.6		
				2' 3"×2' 4",	12.7		
37,	East Boston,	John Sheehan,	4,882	3' 4"×3' 9",	28.5*	1,374	June 30, 1894
					30.0†		
				3'×3' 5",	31.5*		
					31.20†		
40,	Everett and Malden,	R. A. Malone & Sons,	6,252	3' 9"×4' 1",	16.0	6,252	Aug. 31, 1892
41,	Malden and Melrose,	Moulton & O'Mahoney,	9,796	2' 1"×3' 2", 1' 10"×2' 9", 1' 6"×2 6 ,	13.0	9,348	Sept. 29, 1893
41,	Malden,	Day work,	1,014	2' 1"×3' 2", 1' 8"×2' 6",	10.0	1,014	–
42,	Melrose and Stoneham,	David L. Clements,	3,060	1' pipe,	11.4	3,050	Nov. 30, 1892
43,	Somerville and Cambridge,	Metropolitan Construction Co.,	14,450	Main line:		10,612	Oct. 31, 1893
				2' 11"×3' 6",	20.0		
				2' 5"×3' 1", 2' 3"×2' 11", 1' 11"×2 9",	10.5*		
					16.0†		
				1' 6" pipe,	7.0		
				Belmont branch:			
				1' 3" pipe,	7.0		
43½,	Medford and Somerville,	truction Co.,	2,327	3'×3' 7", 2' 11"×3' 6",	18.1	2,312	Aug. 31, 1893
44,	Winchester,		5,603	2' 7"×2' 11", 2' 3"×2' 6", 2'×2'	13.3	3,147	Nov. 30, 1893
44½,	West Medford and Winchester,	Co.,	5,694	2' 11"×3' 3", 2' 9"×3' 1",	8.0	1,395	Mar. 31, 1894
45,	Winchester,	Everson & Liddle,	6,503	2'×2' 5", 1' 10"×2' 3",	9.6	6,164	Sept. 30, 1893
46,	Winchester, Woburn and Stoneham,	Charles Linehan,	5,756	1' 10"×2' 3", 1' 6"×2',	10.5	4,168	Aug. 31, 1893
				1' 3" pipe,	6.2		

* Trench. † Tunnel. ‡ Part of.

Pumping Plant.

Locations of proposed Pumping Stations:

Deer Island: Between the main and outfall sewers of Section 2, and about 250 feet south-east from the new wharf.

East Boston: At Chelsea Creek, on Addison Street, east of the Grand Junction branch of the Boston & Albany railroad.

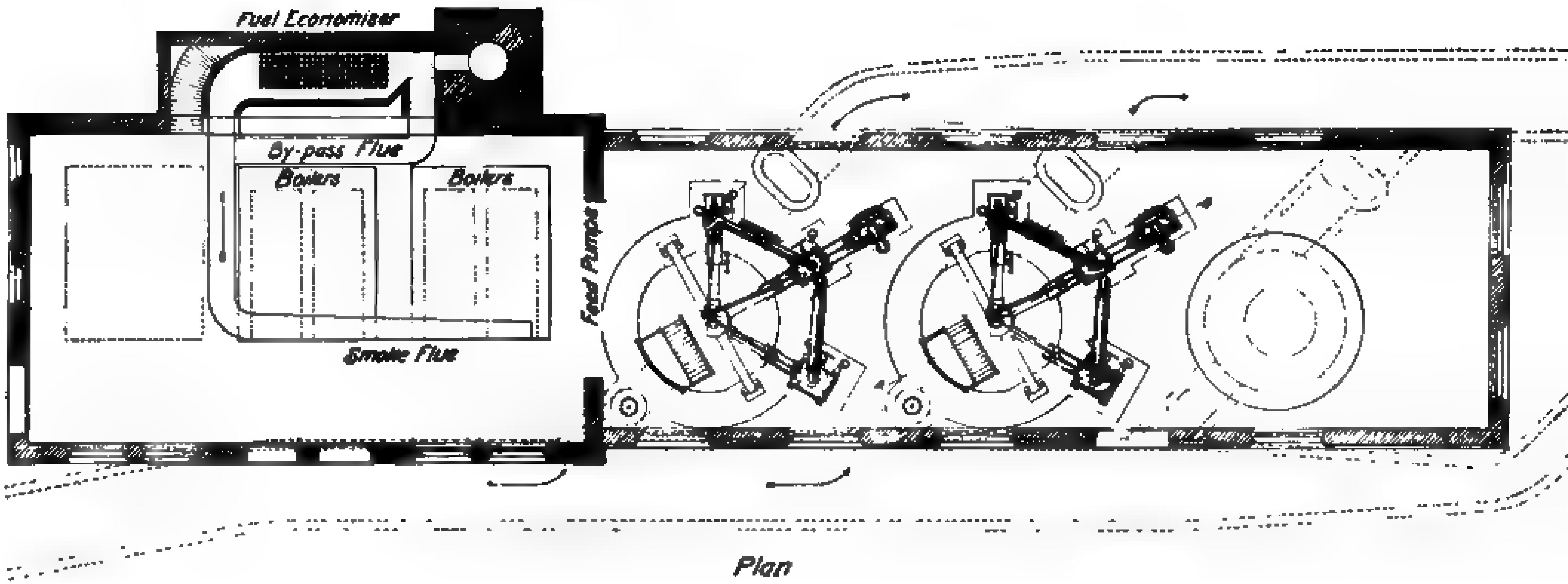
Charlestown: At the southerly end of Malden bridge causeway, in the middle of the Mystic River.

Contractors for the Pumping Plant at each Station:

The Edward P. Allis Company of Milwaukee, Wis.

The plant at each station will consist at first of two pumping engines, with the necessary boilers, piping, etc. Regarding the plant for the first two stations, each engine is to be capable of easily raising seventy cubic feet of sewage nineteen feet vertically above the level of the sewage in the pump-well, and is also to be capable of raising to greater heights, up to twenty-five feet, quantities of sewage inversely proportional to such lifts. Each engine is also to be capable of pumping at as low a rate as fifteen cubic feet per second and at all rates between fifteen and seventy cubic feet per second. The pumps are to be of the centrifugal type, with vertical shafts. The suction and discharge pipes will be each forty-eight inches in diameter. The pump-wheel itself is to be eight feet three inches in diameter, and is intended to run at speeds varying from sixty to one hundred revolutions per minute, according to the amount of sewage and the height to which it is lifted. Each pump-wheel is to be driven by a triple expansion engine of the Corliss type, the three cylinders being set at angles of 60° in order to give uniform turning movement on the crank. The diameters of the cylinders will be thirteen and one-half inches, twenty-four inches and thirty-four inches, and the stroke thirty inches. The discharge channels from the pumps will contain check-valves to prevent any backward flow of the sewage when the pumps are stopped, and the inlet channels from the pump-wells will be provided with gate-valves to admit of closing the passage when desirable.

Regarding the plant for the Charlestown station, the quantity of sewage arriving here is about one-half of that arriving at either the East Boston or Deer Island pumping stations. The two pumping engines will be similar in general design to those at the other two stations. The two pumps are each to have a capacity of thirty-five cubic feet per second raised eleven feet high. The suction and discharge openings will be thirty-six inches in diameter, the diameters of the pump-wheels will be about eight feet, and the



Plan

Scale of Feet

Pumping Station at Deer Island.

Section through Pump on Line A B

cylinders will be ten inches, eighteen inches and twenty-six inches by thirty inches stroke. According to contract all the plant is to be ready for operation during the coming summer.

The duty guaranteed by the contractors for these pumping engines is 75,000,000 foot-pounds per hundred pounds of coal burned for Deer Island and East Boston, and 70,000,000 foot-pounds for Charlestown. In case the duty developed in the test duty trials exceeds or falls short of the guaranteed duty there will be, respectively, a bonus paid, or a fine deducted from the contract price, to be calculated from the following formulæ; —

Deer Island.

$$\text{Bonus} = \frac{\$3,800,000.}{\text{Number of million foot pounds guaranteed.}} - \frac{\$3,800,000.}{\text{Number of million foot-pounds developed.}}$$

$$\text{Fine} = \frac{\$5,300,000.}{\text{Number of million foot-pounds developed.}} - \frac{\$5,300,000.}{\text{Number of million foot-pounds guaranteed.}}$$

East Boston.

$$\text{Bonus} = \frac{\$5,000,000.}{\text{Number of million foot-pounds guaranteed.}} - \frac{\$5,000,000.}{\text{Number of million foot-pounds developed.}}$$

$$\text{Fine} = \frac{\$7,000,000.}{\text{Number of million foot-pounds developed.}} - \frac{\$7,000,000.}{\text{Number of million foot-pounds guaranteed.}}$$

Charlestown.

$$\text{Bonus} = \frac{\$1,300,000.}{\text{Number of million foot-pounds guaranteed.}} - \frac{\$1,300,000.}{\text{Number of million foot-pounds developed.}}$$

$$\text{Fine} = \frac{\$1,800,000.}{\text{Number of million foot-pounds developed.}} - \frac{\$1,800,000.}{\text{Number of million foot-pounds guaranteed.}}$$

It is also provided in the contracts that no bonus shall be paid in excess of $8,000 at Deer Island, $10,000 at East Boston, or $3,000 at Charlestown. It is further provided that in case the duty shown by the trials shall fall short of the guaranteed duty by more than 10 per cent., the plant so falling short may be rejected, but may be used at a reasonable rental until a new plant is procured.

In considering the relative advantage to the State of the different offers made the following factors, among others, were taken into account: Probability of uninterrupted service; cost of fuel, attendance and repairs; first cost of plant (it being assumed that the latter will be or ought to be replaced by a more advanced type

in an assumed term of years); cost of necessary foundations and buildings; interest.

Foundations will be prepared at each station for a third pumping engine, and the work is so planned that a fourth may be added if it should ever be necessary.

The Fire of March 10.

The loss to the State by the fire of March 10 was very considerable, but I have not attempted to estimate it in dollars and cents. About one thousand plans were destroyed, including all of those obtained at the beginning of the work from the State Board of Health. A few calculation books, the cement-testing apparatus and many instruments, etc., were also destroyed, together with a considerable number of valuable technical books (some of which cannot be duplicated), which were the personal property of the writer and the various assistants. The assistant engineer in charge of the records (Mr. Bridgman) and the other assistants promptly placed in one of the safes most of the calculation books and drawings which were then being used in the draughting room, and at the same time Mr. Carter put letter books and other correspondence into the other safe. The contents of both safes were uninjured by fire, but were somewhat injured by water. The danger to our plans by fire was borne in mind at the beginning of the work, and a scheme was arranged and carried out to some extent for duplicating plans and studies and storing one set elsewhere. This considerably lessened the loss. It was unfortunate that the scheme had not been carried out to a greater extent.

Cement Testing.

During the past year about 100,000 barrels of cement have been used, about 55,000 barrels of American natural and about 45,000 barrels of imported Portland. About fifteen thousand tests have been made, to the end that brands unsuitable for the work might be rejected. These tests have been made on substantially the lines described in previous reports. The testing apparatus described in the fourth annual report was destroyed in the fire of March 10. The present equipment consists of a Fairbanks testing machine, tanks for the immersion of briquettes, etc. The briquettes are now made by hand.

The New and Old Mystic Valley Sewers.

The so-called Mystic Valley sewer, from Woburn Centre to the lower Mystic lake, was built by the city of Boston about fifteen years ago. So much of this sewer as lies below a point about seventy-five feet north of the Winchester and Woburn line has been purchased of the city of Boston and incorporated as a part of the Metropolitan system. It was well known when the State Board of Health plan was made that this Mystic Valley sewer did not afford nearly as liberal carrying capacity for the district tributary to it as was afforded by other parts of the Metropolitan system. It was believed however that it would suffice for a long time, and this view had been previously held by the Massachusetts Drainage Commission. But in studying anew the Metropolitan system for this locality it was found that houses built upon certain limited low districts, which were regarded as permissible building ground by the town officials of Winchester, could not be drained into this sewer. It was also strongly urged to your Board by citizens and officials of Winchester that, as the town had to pay, in proportion to its property and the number of inhabitants, as much as any other town or city making use of the system, the trunk sewer serving this district should have as liberal capacity as other parts of the Metropolitan system. It was also urged that before many years the time might possibly arrive when the sewer would not suffice and that an additional trunk sewer to the Metropolitan system would then have to be built in this locality. The local system planned to connect with the old Mystic Valley sewer would then necessarily have to be altered to connect with the new Metropolitan sewer, involving considerable and vexatious changes. After study and consideration of the matter your Board decided to adopt the old Mystic Valley sewer, as at first planned, and to build at once an additional sewer through this locality. Sections 44 and 44½, described elsewhere in this report, constitute this new sewer, which will take the sewage of East Woburn, most of Stoneham and most of Winchester. This new sewer is from four to five and one-half feet lower than the old Mystic Valley sewer, and will provide for the house drainage from the low districts previously alluded to. The old Mystic Valley sewer will take the sewage from Woburn Centre, North Woburn, Cummingsville and a small district in Winchester near the Woburn line.

It appears that the cost of the Metropolitan Sewerage System when completed will be about ten per cent. more than was originally estimated. This statement includes all cost to the State except that for land damages. Settlements have so far been made with only about one-fifth of the owners of private land taken for our work, and it appears impracticable to make any reliable estimate at present as to how the actual land damages will compare with the original estimate. The excess of cost of construction beyond the original estimate may be partly accounted for as follows: The system as constructed has a capacity about ten per cent. greater than that provided for in the original design; Sections 44 and 44½ (the new Mystic Valley sewer, referred to on preceding pages) costing about $75,000, were not originally contemplated and were not estimated for; * the cost of labor, both skilled and unskilled, has very decidedly advanced since the original estimate was made. The statistics used in making the original estimate of cost were destroyed in the fire heretofore alluded to, but the advance in prices may be indicated by a comparison of the cost of the masonry on the eleven principal contract sections of the Boston main drainage sewers with that of like sewers on the Metropolitan System. This comparison shows that the contract brick-work on the latter system has cost thirty-nine per cent. more per cubic yard than that on the Boston system.

The uncertainty of an estimate of cost of deep and difficult work like that on the Metropolitan System can perhaps best be illustrated by examining the bids, which have all been shown in the appendices of this and preceding reports. On Section 14, for example (see page 132, fourth annual report) there were seven bids, made by experienced and skillful contractors, on the items included in the canvass. These bids ran from $148,857 up to $203,596. On nearly every contract section the percentage of variation has been greater than that in the illustration just given.

When will the Metropolitan Sewerage System be completed?

The foregoing question has often been asked, and in order not to cause disappointment very cautious answers have been given. It was said in the report of last year that weeks of hard labor had at times been expended at points on our work without gaining a foot of ground in advancing the sewer, and that other obstacles of equal

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* The old Mystic Valley sewer was purchased for $15,000 less than the sum originally estimated.

difficulty had yet to be contended with. A year has passed since the above statement was made, and many difficulties have now been overcome. Some still remain. It cannot, for example, with certainty be said how long it will take to complete the outlet. The Charlestown pumping station, in the middle of the Mystic River, and the remainder of the siphon, may be built without serious trouble, but, on the other hand, long delay may occur. It, however, seems probable that, if means are furnished, the work will be nearly if not quite completed during the year 1894.

Respectfully submitted,

HOWARD A. CARSON,
Chief Engineer.

APPENDIX.

Table A.

BIDS FOR CONSTRUCTION OF SECTIONS UPON NORTH METROPOLITAN SYSTEM.

NAMES OF BIDDERS.	Residence.	Bids opened Oct. 22, 1892. Section 28. Cambridge.	Bids opened Nov. 5, 1892. Part of Section 27. Somerville and Cambridge.	Bids opened Nov. 12, 1892. Section 43. Somerville and Cambridge.	Bids opened Feb. 11, 1893. Section 37. East Boston.	Bids opened Feb. 25, 1893. Section 46. Winchester and Woburn.
	Chelsea,	$94,866 00	-	$74,090 00	-	-
	Springfield,	94,070 00	-	83,921 50	-	-
	Cambridgeport,	84,427 50	-	81,016 40	-	$13,781 00
	Boston,	88,040 00	$43,045 00	91,570 00	$70,500 00	-
	Lynn,	82,665 00	46,230 00	79,633 50	45,961 00*	-
...n Company,	Boston,	81,558 60	36,560 10*	66,152 70*	53,697 50	-
	Newburyport,	79,080 00	-	114,463 20	-	-
	Everett,	78,722 50	-	-	71,204 00	-
	Jamaica Plain,	76,190 00	45,610 00	55,289 00	61,055 00	19,752 50
National Construction Company,	Boston,	74,028 00	54,240 00	67,467 00	72,443 20	16,780 00
Christopher McBride,	Brighton,	70,470 00	53,565 00	69,345 00	-	-
John L. Reardon & Co.,	Brighton,	70,140 00*	-	-	-	-
Everson & Liddle,	Providence, R. I.,	-	45,420 00	66,960 00	80,800 00	14,407 50
James Killian,	Brighton,	-	-	86,128 70	-	-
Maney & Gannon,	Quincy,	-	-	84,521 50	-	-
Dennis O'Connell,	Dorchester,	-	-	68,718 00	-	16,957 25
F. A. Snow,	Providence, R. I.,	-	-	-	-	18,985 00
Andrew W. Bryne,	Somerville,	-	-	-	-	17,830 00
William B. Bryne,	Everett,	-	-	-	-	17,127 50
Lindsey & Cudmore,	Somerville,	-	-	-	-	15,766 25
Frank L. Allen,	Worcester,	-	-	-	-	14,961 25

* Contract awarded to.

TABLE A — *Concluded.*

NAMES OF BIDDERS.	Residence.	BIDS OPENED MAR. 25, 1893.		BIDS OPENED MAY 13, 1893.	BIDS OPENED JUNE 3, 1893.		BIDS OPENED AUG. 19, 1893.
		SECTION 29.	SECTION 45.	SECTION 43½.	SECTION 30.	SECTION 44.	SECTION 44½.
		Cambridge.	Winchester.	Medford and Somerville.	Cambridge.	Winchester.	Winchester.
Charles Linehan,	Cambridgeport,	$48,490 00	$19,342 50	-	-	-	$32,485 00
H. P. Nawn,	Boston,	52,199 70	-	-	-	-	-
John Sheehan,	Lynn,	-	-	-	-	-	37,155 50
Metropolitan Construction Company,	Boston,	-	-	$18,816 25*	-	-	-
Malone & Tallent,	Everett,	64,327 50	-	-	-	-	-
Jones & Meehan,	Jamaica Plain,	54,632 00	22,610 00	-	$56,786 00*	$33,830 00*	44,900 00
National Construction Company,	Boston,	58,809 40	-	-	-	-	53,005 50
Christopher McBride,	Brighton,	-	-	-	63,430 00	-	35,320 00
Everson & Liddle,	Providence, R. I.,	60,202 50	18,307 50*	22,087 50	64,352 50	36,122 00	39,871 00
Dennis O'Connell,	Dorchester,	-	20,505 00	19,283 75	-	-	-
Andrew W. Bryne,	Somerville,	-	21,575 00	-	-	-	-
William B. Bryne,	Everett,	-	22,662 50	-	-	-	-
Lindsay & Cudmore,	Somerville,	47,534 10*	16,718 75†	-	-	-	-
Frank L. Allen,	Worcester,	-	19,305 00	-	-	-	-
George F. Hersey & Co.,	Boston,	-	34,097 50	-	-	-	-
McCarthy & Heirich.	Everett,	-	23,835 00	-	-	-	-
Crimmings & Collins,	Somerville,	-	-	-	-	-	39,922 50
Thomas J. Young & Co.,	Boston,	-	-	-	-	-	35,098 00
Weaving, Booth & Co.,	Dorchester,	-	-	-	-	-	31,047 00*

* Contract awarded to. † Bid rejected.

TABLE B.

BIDS FOR CONSTRUCTION OF PUMPING PLANTS UPON NORTH METROPOLITAN SYSTEM.

NAMES OF BIDDERS.	Residence.	BIDS OPENED MAY 27, 1893.		BIDS OPENED JULY 1, 1893.
		East Boston.	Deer Island.	Charlestown.
John R. Freeman,	Boston,	$67,000 00	$67,500 00	-
Lynch & Woodward,	Boston,	80,000 00	-	-
Southwark Foundry and Machine Company,	Philadelphia,	63,666 00	64,250 00	$39,375 00
Quintard Iron Works,	New York,	73,750 00	75,000 00	-
Holly Manufacturing Company,	Lockport, N. Y.,	58,500 00	59,500 00	42,000 00
George F. Blake Manufacturing Company,	Boston,	89,612 00	90,287 00	-
Henry R. Worthington (incorporated),	New York,	120,000 00	122,000 00	-
Edward P. Allis Company,	Milwaukee, Wis.,	47,000 00*	47,000 00*	35,000 00*
Snow Steam Pump Works,	Buffalo, N. Y.,	110,352 00	112,500 00	-
Baldwinsville Centrifugal Pump Works,	Syracuse, N. Y.,	53,850 00	54,350 00	-

* Contract awarded to.

Table C.
NORTH METROPOLITAN SYSTEM.

Section.	Location.	Advertised for Bids.	Bids opened.	Number of Bids.	Highest.	Lowest.	CONTRACT AWARDED TO —	Residence.	Amount Bid on Items for Comparison.	Work began.	To be completed.	Length of Section.
No. 28,	Cambridge, .	1892. Oct. 2,	1892. Oct. 22,	12	$94,866 60	$70,140 00	John L. Reardon & Co., . .	Brighton, . .	$70,140 00	1892. Nov. 14,	1894. Apr. 30,	Feet. 6,500
Part of No. 27,	Somerville and Cambridge	Oct. 29,	Nov. 5,	7	54,240 00	38,560 10	Metropolitan Construction Co,	Boston, . .	38,560 10	Nov. 15,	1893. Aug. 31,	2,750
No. 43,	Somerville and Cambridge.	Oct. 29,	Nov. 12,	14	114,463 20	65,152 70	Metropolitan Construction Co.,	Boston, . .	65,152 70	Nov. 18,	Oct. 31,	14,450
No. 37,	East Boston, .	1893. Jan. 21,	1893. Feb. 11,	7	89,800 00	45,961 00	John Sheehan, ...	Lynn, . . .	45,961 00	1893. Mar. 10,	1894. June 30,	4,900
No. 46,	Winchester and Woburn.	Feb. 14,	Feb. 25,	10	19,752 50	13,781 00	Charles Linehan, . . .	Cambridgeport, .	13,781 00	Apr. 5,	1893. Aug. 31,	5,750
No. 29,	Cambridge, .	Mar. 10,	Mar. 25,	7	64,327 50	47,534 10	Lindsay & Cudmore, . .	Somerville, .	47,534 10	Apr. 20,	Nov. 30,	5,150
No. 45,	Winchester, .	Mar. 10,	Mar. 25,	10	34,097 50	16,718 75	Everson & Liddle, . . .	Providence, R.I.,	18,307 50	May 2,	Sept. 30,	6,600
No. 43½,	Medford and Somerville.	Apr. 25,	May 13,	3	22,087 50	18,816 25	Metropolitan Construction Co,	Boston, . .	18,816 25	May 24,	Aug. 31,	2,815
No. 30,	Cambridge, .	May 16,	June 3,	3	64,352 50	56,786 00	Jones & Meehan, . . .	Jamaica Plain, .	56,786 00	June 19,	1894. Apr. 30,	7,020
No. 44,	Winchester, .	May 16,	June 3,	2	36,122 00	33,830 00	Jones & Meehan, . . .	Jamaica Plain, .	33,830 00	June 13,	1893. Nov. 30,	5,600
No. 44½,	Winchester, .	Aug. 1,	Aug. 19,	9	44,900 00	31,047 00	Weaving, Booth & Co., . .	Dorchester, .	31,047 00	Aug. 28,	1894. Mar. 31.	5,700
					$639,009 30	$438,326 90			$439,915 65			
Pumps,	East Boston, .	1893. Apr. 23,	1893. May 27,	10	$120,000 00	$47,000 00	Edward P. Allis Co., . .	Milwaukee, Wis.,	$47,000 00	-	1894. Aug. 31,	
Pumps,	Deer Island, .	Apr. 23,	May 27,	9	122,000 00	47,000 00	Edward P. Allis Co., . .	Milwaukee, Wis.,	47,000 00	-	Aug. 31,	
Pumps,	Charlestown, .	May 14,	July 1,	3	42,000 00	35,000 00	Edward P. Allis Co., . .	Milwaukee, Wis.,	35,000 00	-	Sept. 30,	
					$284,000 00	$129,000 00			$129,000 00			
					$923,009 30	$567,326 90			$568,915 65			

Table D.

MAINTAINING AND OPERATING CHARLES RIVER VALLEY SEWER.

1892.	Dr.			
Oct. 1,	To balance amount unexpended from appropriation of 1892,	. .	. .	$8,750 40
1893.				
Jan. 31,	To appropriation made by chapter 11, Acts of 1893,	. .	. .	26,500 00
				$35,250 40
1892.	Cr.			
Oct. 31,	By amount paid for travelling expenses,	$6 04		
31,	" " for supplies,	1 20		
31,	" " for inspector's salary,	135 00		
31,	" " for labor,	105 36		
			$247 60	
Nov. 30,	By amount paid for travelling expenses,	$7 47		
30,	" " for supplies,	31 96		
30,	" " for labor,	181 98		
30,	" " for inspector's salary,	130 00		
			351 41	
Dec. 30,	By amount paid for travelling expenses,	$21 02		
30,	" " for horse and wagon,	185 00		
30,	" " for supplies,	69 76		
30,	" " for labor,	146 59		
30,	" " for inspector's salary,	130 00		
30,	" " City of Boston for disposing of sewage to date,	5,750 00		
1893.			6,302 37	
Jan. 31,	By amount paid for travelling expenses,	$3 15		
31,	" " for supplies,	2 45		
31,	" " for labor,	62 25		
31,	" " for inspector's salary,	30 00		
			97 85	
Feb. 28,	By amount paid for travelling expenses,	$3 25		
28,	" " for supplies,	28 27		
28,	" " for sleigh,	25 00		
28,	" " for labor,	103 68		
28,	" " for inspector's salary,	130 00		
			290 20	
Mar. 31,	By amount paid for supplies,	$17 08		
31,	" " for labor,	76 00		
31,	" " for inspector's salary,	120 00		
31,	" " City of Boston for disposing of sewage to date,	5,750 00		
			5,963 08	
Apr. 29,	By amount paid for travelling expenses,	$7 20		
29,	" " for supplies,	30 65		
29,	" " for labor,	119 15		
29,	" " for inspector's salary,	135 00		
			292 00	
May 31,	By amount paid for travelling expenses,	$6 90		
31,	" " for supplies,	29 00		
31,	" " for labor,	108 00		
31,	" " for inspector's salary,	125 00		
			268 90	
June 30,	By amount paid for travelling expenses,	$4 36		
30,	" " for supplies,	19 25		
30,	" " for labor,	360 98		
30,	" " for inspector's salary,	135 00		
			519 59	
July 31,	By amount paid for travelling expenses,	$4 00		
31,	" " for supplies,	15 87		
31,	" " for labor,	139 90		
31,	" " for inspector's salary,	130 00		
31,	" " City of Boston for disposing of sewage,	5,750 00		
31,	" " for services of commissioners' clerk, chief engineer, etc.,	550 00		
			6,589 77	
Aug. 31,	By amount paid for travelling expenses,	$25 55		
31,	" " for supplies,	132 24		
31,	" " for labor,	259 10		
31,	" " for inspector's salary,	130 00		
			546 89	
Sept. 30,	By amount paid for travelling expenses,	$6 05		
30,	" " for supplies,	145 13		
30,	" " for labor,	144 00		
30,	" " for inspector's salary,	135 00		
			430 18	21,899 84
	Balance,	. .	. .	$13,350 56

EXPENDITURES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS TO SEPT. 30, 1893.

	Year ending Sept. 30, 1889.	Year ending Sept. 30, 1890.	Year ending Sept. 30, 1891.	Year ending Sept. 30, 1892.	Year ending Sept. 30, 1893.	Total.
Office expenses,	$1,161 29	$28,792 85	$30,437 29	$31,220 76	$35,191 97	$126,804 16
North Metropolitan system,	–	116,492 55	582,966 06	962,798 49	1,172,269 02	2,834,526 12
Charles River system,	–	18,329 41	381,149 33	280,308 29	28,882 27	708,669 30
Both systems,	–	2,696 20	5,597 86	7,703 15	12,783 61	28,780 82
	$1,161 29	$166,311 01	$1,000,150 54	$1,282,030 69	$1,249,126 87	$3,698,780 40

Total amount expended to Sept. 30, 1893, $3,698,780.40.

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR THE YEAR ENDING SEPT. 30, 1893.

Office Expenses.

	1892.			1893.									Total.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Salaries, — Commissioners,	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$9,000 00
Clerk and chief engineer,	833 33	833 33	833 34	833 33	833 33	833 34	833 33	833 33	833 34	833 33	833 33	833 34	10,000 00
Clerical services,	133 33	133 33	145 84	312 33	133 33	133 34	331 66	414 99	381 67	381 66	381 66	381 67	3,264 81
Cement testing,	205 57	210 16	210 16	210 16	210 16	153 01	216 60	179 92	172 45	147 61	147 61	174 52	2,237 93
Office rent,	-	-	-	750 00	-	-	725 42	254 17	254 17	254 17	254 17	254 17	2,746 27
Care of offices,	20 00	20 00	20 00	20 00	20 00	-	-	54 33	26 00	26 00	-	52 00	258 33
Travelling expenses,	9 22	26 05	12 01	14 76	41 98	9 10	27 32	74 65	224 13	92 52	62 15	32 62	626 51
Postage, telegrams and express,	32	51 35	2 61	5 92	22 29	-	38 91	48 78	2 24	49	50 00	32 20	255 11
Supplies,	58 75	148 89	55 16	373 39	324 74	67 61	461 04	1,098 07	447 21	578 20	109 38	502 83	4,220 27
Books and atlases,	4 50	-	35 00	-	-	-	-	85 00	10 85	-	44 00	8 50	137 85
Blue printing,	1 80	5 50	91 52	50 58	53 25	-	8 18	181 74	119 22	-	87 40	152 00	696 14
Photography,	-	-	47 61	52 50	72 51	-	6 84	16 30	44 85	-	28 51	64 48	328 10
Engineers' supplies,	115 05	221 98	35	70 49	143 47	45 90	141 14	25 00	146 43	29 24	124 85	12 00	1,075 90
Engineers' instruments,	-	-	-	36 25	-	29 00	65 00	30 00	168 00	-	-	16 50	344 75
	$2,126 87	$2,400 59	$2,203 60	$3,479 66	$2,605 06	$2,021 30	$3,590 94	$3,996 28	$3,580 56	$3,093 22	$2,818 06	$3,266 83	$35,191 97

OARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893.

North Metropolitan System.

1892.			1893.									Totals.
ctober.	November.	December.	January.	February.	March.			June.	July.	August.	September.	
,858 78	$7,439 62	$15,906 97	$10,823 20	$7,862 16	$11,967 14	$16,456 78	$11,627 33	$11,447 50	$22,683 95	$23,958 23	$21,127 70	$170,158 30
71 01	174 01	216 90	300 02	171 48	39 23	141 36	488 27	250 50	449 57	288 64	465 37	3,045 41
60 60	60 50	279 25	54 69	292 22	4 16	228 95	146 66	350 35	65 14	72 12	269 91	1,883 23
28 26	-	-	-	251 00	-	3 68	-	-	-	5 60	34 90	323 24
-	-	118 34	-	126 31	124 08	-	302 77	782 45	429 91	519 55	326 32	2,729 73
2 90	120 86	679 66	494 30	183 80	36 15	34 63	-	675 00	1,408 65	29 40	2,438 24	6,044 47
1 94	-	-	-	-	-	-	17 08	15 88	-	-	1 00	35 90
15 00	125 00	-	-	965 00	600 00	-	168 00	-	658 90	90 00	20 00	2,621 90
101 46	38 70	188 95	1,126 09	273 43	72 45	1,060 45	1,453 67	1,034 77	1,170 63	1,606 61	2,322 45	10,349 66
-	39 08	2 69	3 09	6 76	-	-	19 50	2 60	56 00	43 00	30 25	251 70
1 25	-	-	-	1 06	-	-	18 22	-	18 74	362 88	54 18	456 32
-	-	100 00	-	355 60	500 00	-	82 40	-	266 80	-	18 00	1,272 80
239 46	1,095 36	2,685 23	2,104 05	4,290 87	1,034 21	710 68	5,853 65	4,116 93	4,946 80	8,528 11	1,565 70	32,060 29
-	381 10	-	-	-	-	349 29	162 67	725 02	227 93	24 00	178 32	2,048 53
065 79	4,607 68	8,666 07	7,116 01	4,849 83	2,048 73	4,565 71	4,721 59	9,798 40	9,628 71	10,676 30	15,347 10	77,977 38
024 00	-	689 92	616 08	121 50	364 50	1,569 63	585 00	88 18	778 40	4,993 23	782 00	12,647 47

ARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR THE YEAR ENDING SEPT. 30, 1893.

Office Expenses.

	1892.			1893.									Total.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
.	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$750 00	$9,000 00
r,	833 33	833 33	833 34	833 33	833 33	833 34	833 33	833 33	833 34	833 33	833 33	833 34	10,000 00
.	133 33	133 33	145 84	312 33	133 33	133 34	331 66	414 99	381 67	381 66	381 66	381 67	3,264 81
.	205 57	210 16	210 16	210 16	210 16	153 01	216 60	179 92	172 45	147 61	147 61	174 52	2,237 93
.	-	-	-	750 00	-	-	725 42	254 17	254 17	254 17	254 17	254 17	2,746 27
.	20 00	20 00	20 00	20 00	20 00	-	-	54 33	26 00	26 00	-	52 00	258 33
.	9 22	26 05	12 01	14 76	41 98	9 10	27 32	74 65	224 13	92 52	62 15	32 62	626 51
r- .	32	51 85	2 61	5 92	22 29	-	38 91	48 78	2 24	49	50 00	32 20	255 11
.	53 75	148 89	55 16	373 39	324 74	67 61	461 04	1,098 07	447 21	578 20	109 38	502 83	4,220 27
.	4 50	-	35 00	-	-	-	-	35 00	10 85	-	44 00	8 50	137 85
.	1 80	5 50	91 52	50 53	53 25	-	8 18	181 74	119 22	-	37 40	152 00	696 14
.	-	-	47 61	52 50	72 51	-	6 34	16 30	44 85	-	23 51	64 48	328 10
.	115 05	221 98	35	70 49	143 47	45 90	141 14	25 00	146 43	29 24	124 85	12 00	1,075 90
.	-	-	-	36 25	-	29 00	65 00	30 00	168 00	-	-	16 50	344 75
	$2,126 87	$2,400 59	$2,208 60	$3,479 66	$2,606 06	$2,021 30	$3,599 94	$3,996 28	$3,580 56	$3,093 22	$2,818 06	$3,266 83	$35,191 97

The item on page 129 — Salaries : engineers, inspectors and others — includes ALL amounts paid for labor on this system during the year.

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893.

North Metropolitan System.

	1892.			1893.									Totals.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Salaries, — engineers, inspectors and others,	$8,858 73	$7,439 62	$15,905 97	$10,823 20	$7,862 16	$11,967 14	$16,456 78	$11,627 38	$11,447 50	$22,683 95	$23,958 23	$21,127 70	$170,158 36
Travelling expenses,	71 01	174 01	215 90	300 02	171 48	39 28	141 36	488 27	250 50	449 57	288 64	455 37	3,045 41
Postage, telegrams and express,	60 59	60 50	279 25	54 89	292 22	4 15	228 95	145 66	350 85	65 14	72 12	268 91	1,883 23
Moulds, patterns and castings,	28 26	-	-	-	251 00	-	8 58	-	-	-	5 50	34 90	323 24
Manhole covers, etc.,	-	-	118 34	-	126 31	124 08	-	302 77	782 45	429 91	519 55	326 32	2,729 73
Land taking, purchase and recording,	2 90	126 85	679 65	434 80	183 80	36 15	34 53	-	675 00	1,403 65	29 40	2,438 24	6,044 47
Maps, plans and blue prints,	1 94	-	-	-	-	-	-	17 08	15 88	-	-	1 00	35 90
Experts and appraisers,	15 00	125 00	-	-	965 00	600 00	-	158 00	-	658 90	80 00	20 00	2,621 90
Tools and repairs same,	101 46	33 70	183 95	1,126 09	273 43	72 45	1,060 45	1,453 67	1,034 77	1,170 63	1,566 61	2,322 45	10,349 66
Boat and boat hire,	-	89 08	2 60	3 00	5 76	-	-	19 50	2 60	56 00	43 00	30 25	251 79
Changing water pipes,	1 25	-	-	-	1 05	-	-	18 22	-	18 74	362 88	54 18	456 32
Medical and legal services,	-	-	100 00	-	355 60	500 00	-	32 40	-	266 80	-	18 00	1,272 80
Cement and gravel,	2,239 45	1,995 36	2,685 23	2,194 05	4,299 87	1,034 21	710 68	3,333 85	4,116 93	4,946 80	3,528 11	1,565 75	32,650 29
Advertising for proposals,	-	381 10	-	-	-	-	349 29	162 87	725 02	227 93	24 00	178 32	2,048 53
Lumber and field supplies,	965 79	4,607 58	3,668 07	7,115 01	4,849 83	2,048 73	4,565 71	4,711 59	9,798 40	9,623 71	10,676 80	15,347 16	77,977 38
Brick,	2,024 00	-	689 92	616 08	121 50	364 50	1,559 63	585 00	83 13	778 48	4,998 23	732 00	12,547 47

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893 — *Continued.*

North Metropolitan System — Continued.

	1892.			1893.									Totals.
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	
Payments on account of contracts: —													
R. A. Malone & Son, —													
Section 3 — Deer Island,	-	-	-	-	-	-	-	-	-	-	-	$150 00	$150 00
Section 16 — Everett, .	$11,394 90	$8,198 08	$9,628 46	$9,879 26	$6,102 14	-	$6,466 51	$3,738 02	$6,975 88	-	$1,000 00	-	63,383 25
Section 23 — Everett, .	-	2,721 94	2,244 20	2,520 25	1,376 05	-	1,347 43	120 26	1,100 00	-	300 00	450 00	12,180 13
Section 40 — Everett and Malden, . .	-	5,118 00	8,062 67	1,700 00	4,799 91	$2,106 29	5,026 08	824 89	2,200 00	-	700 00	550 00	31,087 84
Metropolitan Construction Co., —													
Section 4 — Winthrop,	-	-	100 00	-	-	-	-	-	-	-	-	-	100 00
Section 5 — Winthrop,	-	-	208 23	-	-	-	-	-	-	-	-	-	208 23
Section 6 — Winthrop,	-	-	-	-	-	-	-	-	-	$639 22	-	-	639 22
Section 14 — Chelsea, .	9,462 53	13,834 02	7,759 42	6,035 96	5,488 31	4,978 78	13,208 08	7,167 28	8,951 11	8,000 00	4,108 79	-	88,989 28
Section 17½ — Everett,	-	-	-	-	-	-	-	-	-	1,198 01	-	-	1,198 01
Section 24 — Everett and Charlestown,	-	-	2,000 00	-	-	2,231 27	-	-	-	-	-	-	4,231 27
Part of Section 27 — Somerville and Cambridge, . .	-	-	2,866 57	2,163 95	-	-	3,550 53	5,147 71	1,887 77	7,088 02	6,067 08	2,558 64	31,330 27
Section 43 — Somerville and Cambridge, .	-	-	-	-	-	2,658 37	-	2,674 14	5,155 27	7,303 98	10,881 61	20,064 84	48,738 21
Section 43½ — Medford and Somerville, .	-	-	-	-	-	-	-	-	3,685 18	5,405 47	6,089 86	4,035 50	19,216 51

Trumbull & Ryan, —													
Section 7 — East Boston and Winthrop,	3,157 70	-	3,727 59	-	-	-	799 43	2,424 60	-	1,931 24	-	5,619 82	17,660 38
Chas. Linehan, —													
Section 8 — East Boston, . . .	-	-	-	-	-	3,873 28	-	-	-	-	-	-	3,873 28
Section 9 — East Boston, . . .	-	-	-	-	-	3,517 51	-	-	-	-	-	-	3,517 51
Section 46 — Winchester, Woburn and Stoneham, . .	-	-	-	-	-	-	-	-	2,102 72	2,607 90	3,541 19	3,511 50	11,763 31
Orrin P. Roberts, —													
Section 12 — Chelsea, .	9,600 89	-	6,832 36	135 15	3,194 84	11,004 62	348 92	-	-	-	-	-	31,116 78
Christy McBride, —													
Section 17 — Everett, .	4,185 63	-	3,276 91	3,544 43	5,000 00	-	-	820 50	-	-	-	-	16,827 47
John Sheehan, —													
Section 20 — Medford,	4,612 23	4,366 63	3,804 80	4,653 58	4,477 54	-	1,487 43	1,041 32	1,170 38	-	9,701 11	-	35,315 02
Section 37 — East Boston, . . .	-	-	-	-	-	-	-	-	2,244 14	2,193 65	3,477 89	2,055 33	9,971 01
National Construction Co., —													
Section 21 — Medford,	4,460 80	-	332 98	-	-	4,330 40	-	-	-	100 00	-	-	9,224 18
Andrew W. Byrne, —													
Section 22 — Medford,	4,766 87	3,774 93	7,004 58	-	2,534 61	4,346 28	2,096 20	4,502 90	3,684 87	6,792 15	-	2,877 85	41,880 74
Harry P. Nawn, —													
Section 26 — Charlestown and Somerville, . . .	16,309 27	-	14,132 11	-	7,040 86	4,051 08	3,745 10	-	7,729 90	-	1,750 00	-	54,758 32
McGovern & Ketch, —													
Section 27 — Somerville and Cambridge, . . .	4,529 96	3,437 13	7,915 87	5,776 38	4,582 71	2,602 37	3,932 42	3,607 85	1,778 24	284 30	144 00	12 37	38,603 60

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893 — *Concluded.*

North Metropolitan System — Concluded.

	1892.			1893.									
	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Moulton & Mahoney, —													
Section 41 — Malden and Melrose,	$1,560 64	$2,933 62	$3,210 72	$2,618 23	-	$2,831 32	$6,698 14	-	$4,818 87	$3,216 01	$8,334 46	$12,008 06	$48,230 07
David L. Clements, —													
Section 42 — Melrose and Stoneham,	1,411 16	1,926 09	1,476 37	1,869 30	$290 70	738 19	506 77	$370 42	-	1,000 00	-	-	9,584 00
John L. Reardon & Co., —													
Section 28 — Cambridge,	-	-	5,762 48	5,704 54	-	7,314 02	12,146 14	-	5,208 06	7,614 65	6,199 69	8,043 44	57,993 02
Lindsay & Cudmore, —													
Section 29 — Cambridge,	-	-	-	-	-	-	-	4,537 31	5,530 58	5,257 88	7,875 38	4,376 20	27,577 35
Jones & Meehan, —													
Section 30 — Cambridge,	-	-	-	-	-	-	-	-	-	7,018 00	14,395 85	11,357 31	33,371 16
Section 44 — Winchester,	-	-	-	-	-	-	-	-	-	5,952 63	6,715 41	8,030 60	20,698 64
Weaving & Booth, —													
Section 44½ — Winchester,	-	-	-	-	-	-	-	-	-	-	-	5,826 21	5,826 21
Everson & Liddle, —													
Section 45 — Winchester,	-	-	-	-	-	-	-	-	3,113 49	5,677 55	5,232 41	6,968 82	20,992 27
Mystic Valley Sewer,	-	-	-	-	-	-	-	-	-	52,637 00	-	-	52,637 00
Grand Totals,	$89,822 96	$61,348 24	$114,825 20	$69,267 67	$64,646 18	$73,864 47	$86,470 14	$60,033 40	$96,618 99	$170,297 87	$142,661 80	$142,917 04	$1,172,209 02

EXPENSES OF BOARD OF METROPOLITAN SEWERAGE COMMISSIONERS FOR YEAR ENDING SEPT. 30, 1893.

Charles River System.

	1892. October.	1892. November.	1892. December.	1893. January.	1893. February.	1893. March.	1893. April.	1893. May.	1893. June.	1893. July.	1893. August.	1893. September.	Totals.
Salaries, — engineers, inspectors and others,	$259 00	$25 00	$116 93	$16 28	$25 00	$25 00	$25 00	$25 00	$25 00	$25 00	$25 00	$25 00	$617 21
Supplies,	12 81	60	93 26	35 42	-	20 85	-	27 87	6 25	96 30	51 02	32 27	376 65
Land taking, purchase and recording,	-	1,350 00	-	1,072 00	3,800 00	-	150 00	150 00	-	-	-	50 85	6,572 85
Postage, telegrams and express,	20	-	-	29 00	-	-	-	-	-	-	-	-	29 20
Travelling expenses,	-	2 00	89	10 87	79	-	16	-	1 90	-	-	60	17 21
Manhole covers, etc.,	3 32	-	-	-	-	-	-	-	-	-	-	-	3 32
Payments on account of contracts, —													
National Construction Co., —													
Section C — Brighton,	-	-	-	-	-	-	-	-	-	1,200 00	-	-	1,200 00
Section D — Brighton,	-	-	-	-	-	-	-	-	-	1,300 00	-	-	1,300 00
Jones and Meehan, —													
Section E — Brighton,	4,812 88	-	-	-	-	-	-	-	210 00	-	3,866 00	-	8,888 88
Section F — Newton and Watertown,	-	4,962 78	-	-	-	-	-	-	1,010 00	-	884 00	-	6,856 78
Section G — Newton and Watertown,	-	-	-	-	-	-	-	-	-	-	250 00	-	250 00
Metropolitan Construction Co., —													
Section H — Newton and Watertown,	-	-	2,000 00	-	-	-	-	-	-	-	770 17	-	2,770 17
Totals,	$5,088 21	$6,340 38	$2,211 08	$1,163 57	$3,825 79	$45 85	$175 16	$202 87	$1,253 15	$2,621 30	$5,846 19	$108 72	$28,882 27

Both Systems.

	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	Totals.
Salaries, — engineers, inspectors and others,	$348 34	$1,007 34	$1,027 34	$1,035 50	$1,027 34	$1,330 00	$1,383 00	$1,307 00	$1,424 83	$1,390 34	$1,401 17	-	$12,682 20
Supplies,	28 31	2 00	-	13 00	33 35	-	-	24 75	-	-	-	-	101 41
	$376 65	$1,009 34	$1,027 34	$1,048 50	$1,060 69	$1,330 00	$1,383 00	$1,331 75	$1,424 83	$1,390 34	$1,401 17	-	$12,783 61

ASSETS AND LIABILITIES SEPT. 30, 1893.

Assets.

Office furniture, fittings and supplies, including fittings for field offices, stationery and railroad tickets, . . .			$2,500 00
Engineering instruments and supplies, ...			4,000 00
Engines, pumps, boilers, etc., ...			8,700 00
Derricks, inclines and heavy appliances, ...			1,000 00
Miscellaneous tools, ...			3,600 00
Miscellaneous supplies, ...			1,600 00
Engineers' field offices, sheds, tool houses, etc., . . .			3,700 00
Stock yard and building, East Boston, ...			2,500 00
House and lot, Pearl Street, Chelsea, ...			3,500 00
Vacant lots, Winthrop, ...			1,800 00
Cash received as follows: —			
For services of commissioners, chief engineer and clerk in maintaining Charles River Valley System, ...		$550 00	
For brick bats, ...	$305 05		
Less teaming, ...	12 01		
		293 04	
For rent of house, 63 Pearl Street, Chelsea, .		156 00	
For blue prints and table, ...		3 60	1,002 64
			$33,902 64

There are numerous necessary plans, drawings, calculations and studies relating to the work to which no stated value can be assigned; also between forty and forty-one miles of completed sewer.

Liabilities.

Salaries due engineers, inspectors, rodmen, laborers, and others, ...	$6,667 55
Due for labor in maintaining Charles River Valley System,	85 30
Amounts due contractors for estimates approved, . .	26,702 00
Amounts due sundry parties for cement and brick, . .	9,975 05
Sundry small bills, ...	28,077 60
	$71,507 50

There are also various amounts due contractors upon the several sections of the work which will be paid on succeeding estimates, or after the completion of their contracts.